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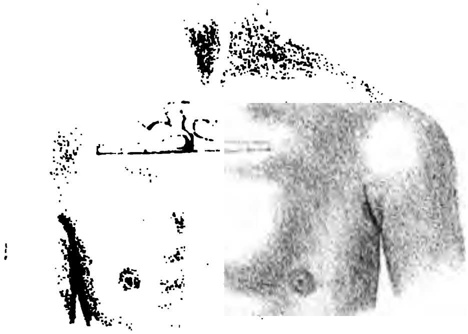

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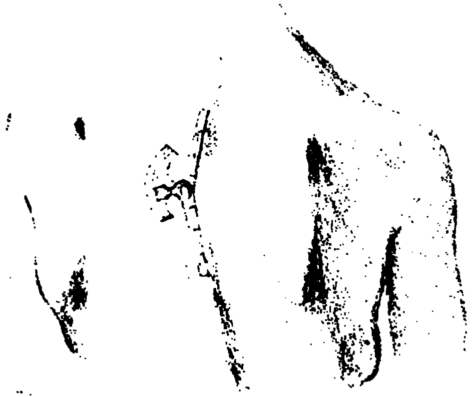

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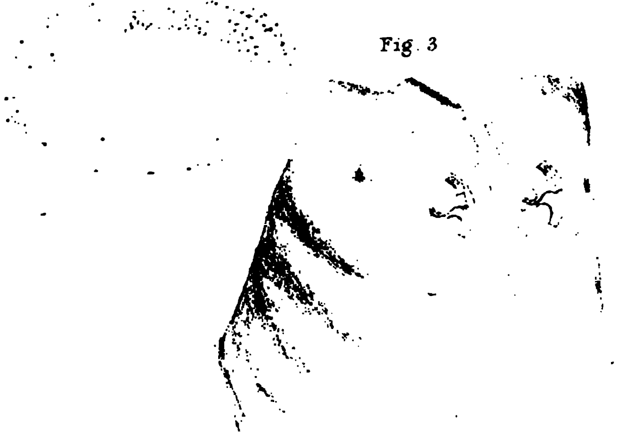

F. H. Johnson Sculp.

THE

PHYSICAL EXAMINATION OF THE CHEST

IN

PULMONARY CONSUMPTION

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AND ITS INTERCURRENT DISEASES.

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BY

SOMERVILLE SCOTT ALISON, M.D. EDIN.

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS, LONDON, AND PHYSICIAN TO THE HOSPITAL
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TO

THE CHAIRMAN, THE VICE-CHAIRMAN, AND THE OTHER MEMBERS
OF THE COMMITTEE OF MANAGEMENT
OF THE
HOSPITAL FOR CONSUMPTION AND
DISEASES OF THE CHEST,
BROMPTON,
This Work is respectfully Dedicated
BY
THE AUTHOR.

PREFACE.

The chief object of the Author in the following work has been to give a detailed account of the leading physical signs of the chest, &c. in pulmonary consumption. It has appeared to him that it would be to add to the means of the diagnosis of this important disease to describe them at greater length than has yet been done. Some of the signs have been treated more largely than before; some have been described, it is believed, for the first time: as a whole, they have been comprehensively dealt with: their mechanism has been regarded, and the phenomena of physical science have been freely adduced to serve in their illustration.

The most important signs, in a practical point of view, have been particularly regarded; but no ascertained sign of pulmonary consumption has been altogether omitted, for the Author, he believes justly, has felt that the movements, and the form, and the sounds of the human chest in disease, illustrating and depending upon physical laws, not less than the movements, the form, and sounds of other things in nature, must be full of interest to the physician, — the enlightened physician of these days, — even when leading to no immediate and obvious practical advantage.

A minor, though an important object, has been to give some practical directions for the examination of the sufferer from pulmonary consumption, and to offer a full account of the instruments employed in exploration, and of the principles of their construction, and of their mode of operation. In furtherance of this object, various papers written by the Author, and published within the last few years, have been added to the work.

The Author's position of Physician to the Hospital for Consumption has afforded him the most ample means of observing the signs he has described. These, both in a practical and a scientific point of view, have had an absorbing interest for him ; and this, perchance, may have on some occasions led him to be prolix. The concentration of thought which they favour, and the opportunities which they afford for investigation, are believed by many to be among the most important advantages of special hospitals,—centres for relief and study,—which have happily been accorded a secure place amongst the most valued institutions of modern times, and of this progressive and labour-dividing age.

Much of the materials upon which the following descriptions are based, much of the means for testing instruments, and of general observation, have been found in the hospital to which he has the honour to belong.

His colleagues have greatly aided the Author. The observation of their practice, and the instruction which has casually fallen from them, have been a guide to him. He would thus gratefully acknowledge their aid ; but at the same time, he by no means desires to shelter himself from criticism for his opinions, for which he holds himself alone responsible.

The Author has departed from the established division of pulmonary consumption into three stages. He has found perforation or pneumothorax so common an event, and it is signalized with such strongly-marked characteristic signs, that he has been induced to make this pathological condition a stage by itself,—the concluding stage of the disease. This arrangement will contribute, the Author believes, to the more careful study of this very remarkable condition, as well as lead to its more frequent discovery.

The subject of thoracic acoustics has obtained much consideration in this work, because this branch of knowledge proves an easy key to the physical condition of the interior of the chest.

The differential stethoscope, and its remarkable auditory revelations, have been largely dealt with, because they certainly aid materially in diagnosis.

The plural number has been employed when general statements have been made, in which the reader might be supposed ready to concur. But when facts have been detailed, resting on the Author's individual authority, the singular number has been preferred.

LONDON: 80 *Park Street, Grosvenor Square;*
Feb. 7th, 1861.

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CORRIGENDA.

Page 4, line 4 from foot, "is" *for* "are."
" 5, " 12 " "enables" *for* "enable."
" 286, " 10 " "air" *for* "ear."
" 269, " 10, "breath" *for* "health."
" 427, " 11, "January 31, 1856," *for* "January 31, 18, 1856."

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EXAMINATION OF THE CHEST &c.

IN

PULMONARY CONSUMPTION.

PART I.

CHAPTER I.

Symptomatic and Physical Evidence compared. — Disorder of Organs denoted by disordered Functions. — Products of the Lungs not known to be altered in Disease.—Disorder of minor Functions.—Physical Properties of Organs aid in Diagnosis.—The acoustic Properties of Lung.—Form and Movements of the Chest.

If the question were proposed to me, whether, in the case of a patient supposed to suffer from pulmonary consumption, I would be disposed to regard as the more decisive of the question, evidence afforded by symptoms, or that given by the physical signs ascertained by the examination of his chest, I would reply, that I should much prefer the physical signs as the grounds upon which to form my judgment. The symptoms of pulmonary consumption are much more the symptoms of other diseases, than the physical signs of pulmonary consumption are those of other maladies. The short cough, the frothy scanty sputum, the slight shortness and quickness of breath, the quickened pulse, the debility and languor, and the loss of weight, which are the symptoms of pulmonary consumption in its first stage, are not uncommonly the symptoms of other diseases, such as bronchitis, bronchial or tracheal or laryngeal irritation, dependent upon, or connected with gastric, hepatic, or even uterine irritation, and general decline of health. On the other hand, the dullness, or flatness, or shortness of the percussion note; its loss of symmetry, so to speak; the harsh or quasi-tubular inspiration, perhaps divided, with its dry crack and click under the clavicles; the coarse prolonged expiration, with or without its fine crumpling bruit; the defective elevation or expansion of the upper and front part of the thoracic cone, on both sides, or what is stronger, on one side; the strong vocal resonance and fremitus deprived of its relative proportion of one degree more on the right than on the left side; and the systolic bruit of the pulmonary and subclavian arteries, at the same time that other parts of the chest evince the usual characteristics of healthy vesicular breathing, and the heart is free from morbid sounds, — are seldom present without tubercular deposit in the lung.

The symptoms of pulmonary consumption are more variable in their accession, than the physical signs; some, or even many of them may be nearly or altogether absent, during the whole course of the disease. They may escape the attention of the patient, or from motives of interest, or from self-deception, he may deny their presence. Though once experienced, they may absent themselves, and leave no trace behind. It is different with physical signs; they are very regular in the order of their succession; they are generally all found to lend confirmation and strength to each other; they cannot be denied by the patient, and they are little liable to vanish, or if they do disappear, they are succeeded by other signs well known to be their successors, and still more demonstrative of the nature of the disease. The worst symptoms of advanced phthisis often present themselves unpreceded by scarcely a symptom which has attracted notice; but we know of no cases of this disease marked by advanced signs unpreceded by the preliminary ones just noted.

If such be the comparative value of the symptoms and the physical signs of phthisis in its first stage, what shall we not say of the greater value of the signs in the latter stages of the disease? The cough, emaciation, sweatings, and quick respiration, the hæmoptysis of advanced phthisis, are simply as suspicions to the modern physician, compared with the moist crepitation, the dull percussion, the gurgling, the cavernous respiration and cavernous voice, which are as so many certain proofs. When the wasted, coughing, panting patient is seen by the physician, he desires at once to examine the chest before deciding upon the nature of the disease. He is far more desirous to learn the physical signs in such a case than he would be in another case to acquire the symptoms, when he has already learned that the physical signs above noted are present. When the physical signs are manifested to his senses, the symptoms, so far as the nature of the case is concerned, are now of little value, however truly important they may be in respect of the relief of the patient.

Yet it must be admitted, that in a large number of cases of phthisis, at an early period of the first stage, there is much reason to confess that physical signs are little developed. Numerous examples of phthisis, at an early part of the first stage, present themselves without our being able to detect physical evidence that can be held to be decisive. Even in examples of the disease of some months' standing, occurring in my own practice, physical signs have been so ill-marked as to have justified suspended judgment, and it has been only by means of subsequent evidence, that a decided conviction could be arrived at, that the disease was all along pulmonary consumption. It is at the early part of the first stage chiefly, that the defective development of physical signs is thus found to render diagnosis difficult.

When an injury has been inflicted upon an organ, when its action has been disordered, or when in the simplest inanimate machine a disturbing force or injury is in operation, the fact is revealed, or tends to be, by some disorder in the office discharged by the organ or the machine. The disordered action in either case may be great, and easily recognised, or it may be so very slight as to prove difficult of appreciation to our senses. If the suffering organ be an internal one, and the extent of the disordered action be small, to the ordinary inquirer the indications of suffering in the affected organ may be with difficulty observed, or may be altogether unappreciated; and this may be the case although the general health is manifestly declining.

In the case of secreting organs, if a disturbing cause be in operation, we naturally look for some departure in the secretion from its normal state. This departure may be one of quantity, or it may be one of quality. In disordered conditions of the liver and kidney, we find disordered states of the bile and urine. In diseased states of muscles and of their motor nerves, their conditions are revealed by excess, irregularity, partial or total loss of motion, and other events relating to the functions of the parts. If however we endeavour to apply to incipient tubercular disease of the lungs this method of inquiry, i. e. if we seek to discover some alteration in the ultimate function of the organ, we altogether fail, not perhaps because the inquiry is absolutely hopeless, but because, with our present means of investigation, we cannot discover any difference in the ultimate function of the parts, viz. the elimination of carbonic acid gas and watery vapour. These are comparatively simple products; their chemical composition cannot vary, their chemical and mechanical properties cannot alter. The amount of these products may be varied by disease, but as the amount is liable to vary at all times, and under ceaseless influences, not morbid only, any evidence of this kind is of comparatively little value. Besides, deficient amount due to one portion of the organ, may be compensated for by excess due to another part.

It is just possible that other products, due to the action of the lungs, and appertaining to what may be called their ultimate functions, may exist, may yet be revealed, and may offer such modifications as to disclose the presence of disease; but this consideration belongs rather to the possible or probable medicine of a future day, than to the actual science of the present hour.

Abnormal constituents in the expired air may possibly some day serve to reveal pulmonary diseases, in the same manner as abnormal constituents of the urine serve in fact at the present time to denote and prove the existence of disease of the kidney. At present no such kind of evidence is available in respect of the lungs. When the examination of the proper or ultimate function of an organ fails to declare the presence of disease, we are wont to continue the inquiry by searching into what may be called the lesser functions of the part, viz. those which are subservient to the ultimate function; such, for instance, as the peristaltic motion of the stomach and bowels in digestion, and in the conveyance of the residue of the food. This motion may be defective, it may be excessive, or it may be reversed. Instead of being painless, it may become painful. Such an inquiry in the case of disease of the lungs is of great avail.

The physical or mechanical condition of the organ too, its size, its consistence, the character of its surface, and its behaviour under physical forces, are brought into requisition in the search for disease, and this mode of examination proves of pre-eminent utility in the presence of disease of the pulmonary structure. It fortunately happens, that the performance of the functions of the lungs are attended with many minor or lesser offices which are fully appreciable to our senses, and since these are sensibly affected by modification in the organic condition of the lungs, the state of these minor offices proves a source of abundant evidence of the presence or absence of disease. The penetration of air into and out of the lungs, is a necessary condition to the ultimate discharge of the duties of the lung, and this penetration is marked by a certain sound occupying in health a pretty clearly defined portion of time. The same thing holds with the forcing of the air from the lung. A lung duly permeated with air permits the expansion and elevation of the ribs and sternum, and in a certain period of time; and a lung duly freed from air, during expiration, permits of a falling and contracting of the chest, and also in a certain time. When these minor functions are impeded, the changes in the sounds, movements, and shape of the chest are modified, and a tendency to this modification must exist from the very earliest period of the organic change. A lung permeated with air, affords to its enclosing case, the bony thorax, a resonant note on percussion, which is constantly tending to a flatness and shortness in duration, a dullness as the contained air is diminished by organic changes. The property of conveying sound is affected by organic alteration.

The property of weight, too, is altered by the deposition of tubercular products in the lung, and at an early period of the disease; but no means are yet within our reach, by which we can, during life, determine the weight of the chest or lung, separate from other parts of the body. This incident of increased weight in tubercular disease of the lung, from the internal position of the organ, is of little avail in coming to a decision in diagnosis.

The movements of the lungs and heart are accompanied by certain sounds, and these are greatly modified by the various physical conditions of the parts. They are also greatly modified with the varying condition of the parts through which they travel to the thoracic walls. The knowledge of these modifications of sound enable us to infer the physical condition of the contents of the chest. This is the foundation of the art of auscultation, which has imparted an extraordinary exactitude to the diagnosis of diseases of the lungs. The form and movements of the walls of the chest are greatly affected by the size, shape, and even consistence of the contents of this cavity, and lend a most material aid in diagnosis. Certain deviations in the form and movements of the chest, it will be found, attend certain diseased conditions with such remarkable regularity and exclusiveness, that it frequently happens the latter may be inferred from the presence of the former.

CHAP. II.

FIRST STAGE: AUSCULTATION.

Vesicular Respiration.—Harsh inspiration Sounds: Aid from Differential Stethoscope.—Deficient Duration of harsh Sounds: Aid from Differential Stethoscope. — Harsh Sounds occasionally associated with moist Crepitation, &c. —Simulation of harsh phthisical Respiration. — Natural Harshness on left Side. — Mechanism of harsh Sounds. — Associated moist and humid Crepitation, and their Mechanism.

The very first thoracic physical signs which are made sensible to us in the first stage of phthisis, that of crude tubercle free from softening and cavities, certainly relate to the vesicular respiration. The alteration in the percussion note, and in the visible movements of the thorax, occurs, there is reason to believe, in most cases at least, long after. Were all cases carefully examined at the very commencement, this order would doubtless hold without exception.

The alterations affecting the vesicular murmur relate first to itself, and secondly to its duration, absolute and comparative in respect of the expiration, and also to its continuity and equality.

The alteration in the sound itself is a certain harshness and increased loudness. This is almost invariably present at the very first deposition of tubercle. At first it is attended with little or no deficiency, but after a time, as the deposit proceeds, a certain deficiency is recognised. This harshness is heard, of course, at the usual preferential seats of tubercle, the apex of one or other lung, and is best heard above and below the clavicle near its humeral extremity. It is heard about as frequently on one side of the chest as upon the other, according to my tolerably well analysed experience. The harshness varies of course in different cases in character, but it is not inaptly described as approaching a fine sawing bruit, compared with the fine full gentle rustle of healthy vesicular respiration. It is recognised and made very manifest, by cleverly moving the wooden stethoscope from the seat of harsh respiration to a healthy part, taking care to listen at both parts under the same condition as far as that is possible, in respect of the patient, of the stethoscope, and the auscultator's ear. It is, however, far better dealt with, with my differential stethoscope. With the two sound receivers applied respectively to the suspected part and to a healthy part, which may be either upon the same side, but lower down, or upon the opposite side. The harshness may be readily made out by quickly succeeding observations.

These succeeding observations are thus very accurately taken, for the conditions in respect of them may be readily made exactly alike. Precisely corresponding parts of the two sides may be selected; no effort is made by the patient to change his position, the application of the instrument is so easy and painless that he never winces, and the auscultator's hand or ear may be kept entirely motionless.

As the deposition of tubercle progresses the harshness increases, and if the differential stethoscope be employed with one sound-receiver over the diseased part, and the other over a healthy part with normal soft respiration simultaneously, this latter sound is lost, or tends to be lost, and the only sound heard is that of coarse harsh respiration communicated to the ear connected with the diseased part. The difference is thus very effectively made out, and in such a satisfactory manner as is not to be procured by the ordinary stethoscope. For this result a decided loudness must exist.

Diagram representing harsh respiration sounds on one side of the chest, and silence on the other and healthy side; the differential stethoscope being simultaneously employed. The black circle represents heard sound, the dotted one denotes sensorial silence.

Unhealthy side,
With loud harsh respiration sounds:
Heard.

Healthy side,
With gentle respiration sounds:
Not heard.

The harsh sound of tuberculating lung soon becomes deficient. I believe harsh deficient sounds commence at the same moment as the murmur of healthy lung, but they cease before the latter terminates. This loss of synchronosity in the cessation of the sounds of two parts is in some cases with only moderate harshness made out by the differential stethoscope, for this instrument enables us virtually to place our two ears where we list, and to compare the beginning and the termination of the sounds in different places with perfect accuracy,—an advantage which is not secured by any other means. The healthy vesicular respiration sound of one part is heard to continue through one ear when the harsh respiration sound of another part has ceased to be heard through the other ear. The deficiency in some cases becomes marked when, in addition to this sign, an opposite one of excess of a compensatory character is established in a healthy part, as when we have puerile breathing.

Harsh defective respiration sounds in phthisis are generally observed alone in the commencement of the disease. In acute cases, as those occurring in the course of exanthematous maladies, they are frequently attended with another sign, and this is moist crepitation of the second degree of fineness. In such cases both the harshness and the moist crepitation are heard almost invariably throughout the entire chest. In chronic examples of phthisis, a dry click or crackle is occasionally associated with harsh respiration.

The harsh respiration of phthisis may be simulated by, and is sometimes mistaken for, the harsh respiration of other conditions. The respiration of nervous females is wont to become harsh, but this condition is, for the most part, general over the chest; a degree of nervous excitement may be observed in the expression; and this form of harshness becomes reduced as the patient and the breathing calm down. The respiration of such females is seldom deficient, but, on the contrary, is generally full and protracted. The compensating respiration of healthy lung is occasionally harsh, but it is full and protracted. I have found vesicular respiration at the apices, and the mammary regions to be harsh where the disease has been confined to solidification of the base; but the clear percussion of the vesicular parts, and the dull percussion with deficient respiration, with râle and rhonchus, have served to determine the true nature of the harshness. The respiration sound at the base occasionally becomes harsh and loud when that part is compensating the reduced respiration of the consolidated or excavated apex.

In estimating the true value of rather harsh and loud respiration on one side of the chest, as indications of disease, the following facts are to be borne in mind. The vesicular respiration of many persons in health varies a little in intensity at the two apices. I have heard an excess of natural respiration sound approaching harshness on one side when there has been no disease whatever of either lung. This excess has been observed by me to hold much more frequently on the left side than on the right. In examining about a hundred boys and girls, and young females in health, I have found an excess of loudness of vesicular sound on the left side of the chest in about ten. Nearly the whole of the remaining ninety have had equal respiration on both sides. It is not easy to assign a reason for this excess of loudness on the left side. However, I am disposed to believe it to be dependent upon the greater degree of angularity and curving of the bronchial tubes at the left apex, and to some impediment offered by the presence of the heart on that side.

The mechanism of the harshness of respiration in the early stage of phthisis is due to the increased resistance which the air, drawn into the larger bronchial tubes by the expanding cavity of the chest, has to overcome in the terminal bronchi in passing into the ultimate vesicles, through the presence of surrounding tubercles, and to the resistance offered to the expansion of the cells themselves partially filled, as many of them are, with tubercle corpuscles, and by the presence of surrounding vesicles laden with that material. The friction of air passing along a fine tubule, pressed upon by tuberculated vesicles and agglomerated tubercles, is greater than in the case of a tubule surrounded by soft light aerated vesicles. The vesicles themselves, laden or partially laden with tubercles, will dilate with more resistance than free vesicles, and more noise will be produced; for resistance to motion, to a certain extent, increases sound. Even healthy vesicles will expand with more noise when surrounded by lung rendered even slightly more dense by the presence of tubercle corpuscles, for the resistance will be increased.

Harshness of respiration sound is due likewise to the greater velocity which marks the passage of a given quantity of air in a narrowed tube. The deficiency in amount and duration of respiration is to be attributed to the smaller amount of vesicular structure that can be inflated. The reason of the respiration being of shorter duration appears to be this: the process of expansion of the cells is early concluded, being comparatively slight in amount. The resistance to the act, though sufficient to produce a harsh quality of sound, is as nothing as yet in the presence of the inspirating forces, and totally unable to protract the vesicular dilatation that is at all possible. The chief impediment to inspiration, in the case of harsh deficient sound, occurs at the termination of the act. It is rather a sudden absolute stop which occurs to the entire act, and not a pause taking place during the progress of the act, to be overcome by increasing force, as in the expiration of phthisis, which may be, and generally is, long. In inspiration, the air is absolutely stopped, can proceed no further, and therefore the bruit too is early suspended, the air not being capable of passing beyond the source of the impediment. In expiration on the other hand, the impediment is experienced in the course of the discharge, and the air may yet, after the temporary obstacle is overcome, by the accumulating force of the contracting and yet elastic lung, and the collapsing walls of the chest, pass on, and be discharged by the trachea and glottis; the sounds of the expiration of air being continued during the whole movements. In divided and "wavy" inspiration, the impediments operate to produce a pause or abatement during the course of the sound.

The mechanism of the click, or clack, or dry crackle, is this: the fine bronchus or tubule being pressed upon by the superincumbent tubercle, the opposite sides come in contact; these sides adhere the more readily that they are covered with a more than usually adhesive mucous secretion; the advancing column of air drawn along by the increasing expansion of the chest, after perhaps a temporary but almost unappreciable check, breaks asunder the connected sides of the tube, the connecting mucus drawn out into a quasi membrane, suddenly ruptures, the ruptured sides suddenly recoil, the air passes, and the sides of the tubules separate; the result is, that a quick sudden motion is produced by the air overcoming an obstacle, and a noise is caused, which we designate or describe as a click, or clack, crack, or crackle. This noise may be imitated by placing the lips wetted with saliva together, and suddenly separating them.

The humid or moist crackle, which occasionally accompanies harsh respiration, is produced by the breaking or rupture of small bubbles of air, composed of particles of air involved in walls of liquid secretion in the bronchial tubules, or by the passage of air through thin secretion in the same parts. But of moist crepitations and other allied bruits, we have to speak at greater length at a more advanced part of this work, when the less early stages of consumption are brought under notice.

CHAP. III.

FIRST STAGE: AUSCULTATION—*continued.*

Feeble deficient inspiration Sound.—Diagnosis and Aid from Differential Stethoscope.—Healthy respiration Sound may, by comparison with unhealthy harsh Sounds, appear unhealthy.

The vesicular inspiration instead of being harsh, not infrequently is feeble and little audible in the first stage of phthisis. The feeble respiration sound, of which I now treat appears to me, though feeble, to partake less of the fine divided character proper to vesicular respiration than the harsh breathing sound of which I have just written. It has, according to my experience, occurred at a later stage than harsh respiration sound, or when the deposit of tubercles has been more general in a part — and more annihilating, so to speak, of vesicular movement. It is more a negative than a positive alteration of healthy breathing sound. It is frequently more remarkable for the absence of the finely divided rustling healthy respiration bruit, than for any positive quality, to which it is easy to give a name. The term indeterminate, which Skoda so frequently employs, is often happily applicable to the defective or feeble breathing of phthisis. Feeble defective inspiration sound of phthisis is so marked in some cases, as to make itself known as such by the application of the wooden stethoscope to the diseased part only. It is however generally made most manifest to the mind by comparative examination with other parts. But the differential stethoscope, in cases of *considerable* deficiency, used simultaneously, affords the best evidence. Inspiration sound is audible at healthy parts, and inaudible at the diseased point. The reverse of what occurs in the cases of harsh respiration. It is liable to be mistaken for the natural respiration sound of some persons advanced in life, which is scarcely audible, in persons of calm temperament, of slow circulation and respiration, and who are rather corpulent. In these persons, however, attentive listening will detect an inspiratory bruit, normal in length, although ill pronounced in pitch and intensity. This character of respiration sound is general over both sides of the chest, which is not the case in the feeble respiration of phthisis. The differential stethoscope will, under such circumstances, prove of great utility. The feeble inspiration sound of the first stage of phthisis, may be mistaken for the *very deficient* inspiration sound of dry old cavities. I believe this to be a rather common error. The respiration of many cavities which are dry, of no great size, which have free bronchial communication, both intra and extra, with little or no mucus at the openings of the bronchi, to produce bubbling or clicking, free from distinct cavernous pectoriloquy, approaches the character of feeble vesicular respiration. The noise is that simply of air passing along a tube, or in a space free from the somewhat divided, opposed, or rustling character of vesicular respiration. The approach to feeble ill-formed vesicular respiration sound is such, that it may be, and often is, confounded even by practical stethoscopists with the feeble condition of breathing in the first stage. The differential stethoscope under these circumstances proves of some value. Both sound collectors being applied, one on the sound side, and the other on the feeble side, the result is such as to convince the hearer that very different conditions of lung are present at the two parts. If the feeble inspiration sound be proceeding from a dry cavity, the contrast is *very great*, when the two parts are listened to in succession; such as is scarcely ever obtained in the case of healthy lung, contrasted with phthisical lung in its first stage of degeneration. If the two cup collectors be simultaneously employed, the ear which is connected with the sound lung is the only one which, to the mind, seems to receive any sonorous impression, which is hardly the case when the two ears are listening, one to a healthy lung and the other to a lung the seat of tubercle in its crude or nascent state, and while yet in very moderate amount. The absence of hearing through the ear connected with the diseased side, always indicates some very considerable amount of deposit, or some form of very serious or advanced disease. When silence is not due to a large amount of crude tubercle, it is generally an old dry vomica that is present, but total hepatisation will produce the same result, but this hepatisation of the apex is extremely rare. Deficiency of inspiration sound, productive of the same result, may be induced by pressure on the chief bronchi, by tumours originating in the mediastinum or root of the lung, by aneurism of the aorta, and by complete filling of the pleural cavity of one side by effusion; but in these comparatively rare cases, the proper signs of these diseases respectively will declare the nature of the malady. I have in a few cases seen cancer of the lung produce such an amount of feebleness of respiration as to cause respiration sound to be obliterated, so to speak, when the sound collectors of the differential stethoscope have been employed simultaneously upon the diseased and healthy parts. In these cases too, a stridulous pipe sound served to denote great pressure.

The depression of the ribs, and the inward dragging of the intercostal soft parts, the presence of cavernous pectoriloquy, and the long duration of the disease, will generally suffice, moreover, to indicate that the feeble inspiration sound is that of a cavity. It is ever to be remembered, that the feeble respiration of a lung with a moderate amount of crude tubercle, is very incomplete, compared with the feeble respiration of a cavity, and the expiration, unlike that of many cases of cavities, is never cavernous. Let me be understood : I speak of the feeble respiration of certain cavities only ; I am fully aware that the dry respiration of some few cavities, in which much friction with the air takes place, is very loud, and tends to obscure or eclipse the vesicular respiration sound of healthy lung, when the differential stethoscope is employed with its two sound collectors at once. Feeble inspiration sound, in the first stage of phthisis, is for the most part unattended with marked depression of the ribs, or with great loss of curving. The intercostal spaces are not often retracted. The voice may be bronchophonic, with undue vibration and fremitus, but it is never, of course, cavernous, nor does it ever seem to proceed immediately from under the skin simply into the stethoscope. The percussion is often clear, it may be flat, or short and acute, but it is seldom short wooden, or absolutely dull.

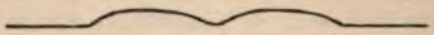
In resolving the question, whether a respiration sound which is feeble on one side, compared with the respiration sound on the other side, be morbid, we must bear in mind, that the natural respiration sound may appear weak and deficient, when compared with the unhealthy harsh respiration sound of a diseased part. To decide which is the diseased side, when neither the harshness nor the deficiency is well marked or associated with other signs, is often exceedingly difficult. This difficulty is very considerable, when the loudness or harshness is heard on the left side, where it is not uncommonly normal. It is well not to rely very much upon a slight difference, particularly if the fullness be upon the left.

CHAP. IV.

FIRST STAGE: AUSCULTATION—*continued.*

Wavy inspiration Sound, and its Mechanism and Diagnosis. — Divided inspiration Sound, and its Mechanism and Diagnosis. — Differential Stethoscope. — Jerky inspiration Sound.

The vesicular inspiration murmur of healthy lung is an even, continuous, and uniform sound, observing the same pitch and character throughout its whole duration. But at an early period of phthisis, in its first stage, though later than the period for the advent of harsh respiration, this uniformity is frequently lost, and the murmur falls and rises in pitch and intensity, it may be, one, two, or even three times during its continuance. Were the murmur denoted by a line, it would assume this form: —



I have generally found the murmur that is thus deprived of its uniformity to be harsh, and I think the murmur is rather more harsh just after its fall. The murmur is such, so coarse and harsh, that I am disposed to think it is generally a good deal made up of the friction sounds of the ultimate and penultimate bronchial tubules. I have very frequently observed this waviness or undulation of breath sound in company with symptoms and other physical signs, calculated to support the inference that tubercle, in a crude dry form, was present in the lung.

My late respected friend, and my predecessor in the office of Physician to the Hospital for Consumption, Dr. Theophilus Thompson, paid particular attention to this sign, and, as far as I am aware, was the first observer to call attention to it. He believed it to form good evidence of the presence of tubercle in a nascent or crude unsoftened state. He has designated this modified breath sound as *wavy* respiration. According to my experience, it is frequently found at one apex, the diseased one in phthisis, when tubercle in a dry state has been laid down to an inconsiderable extent, and I accept it as a corroboratory sign, together with other evidence. This waviness is due to the presence of an obstructing force to the suction of air into the vesicles, consisting in the loss of the dilatability of the lung structure to a degree sufficient to produce a *retarding* effect without even for an instant absolutely stopping the movement of the air. If this explanation be correct, the expiration should be prolonged in such cases, for the increased density of the lung and the compressed state of the tubules should suffice to prolong the outward movement of the air. Now, in such cases, we have this very effect, and the expiration sound is distinctly long and coarse.

I have reason to believe that wavy inspiration is not unfrequently present when no tubercles or other morbid depositions are in operation. The respiratory movements of the muscles of delicate and agitated females sometimes act irregularly and with the loss of their normal uniformity; and the result is, that the suction power being irregularly exercised, the motion sounds of the incoming air are irregular also, and acquire an undulatory character. Such an undulatory condition of the inspiratory sound, however, is to be distinguished by the undulation caused by tubercle, by the former being heard on those sides of the chest, per totum thoracem, while in the latter case, the waviness is confined, for the most part, to one or other apex, or if found in both, the long expiration sound, and such other signs as a click, will be present to reduce the difficulty. The waving inspiration sound of nervousness is not followed by long expiration sound, except when the inspiration has been unusually long. I have heard the wavy inspiration in many nervous females free from phthisis, and I have often heard it when the heart has been rapid in its action from nervous excitement. When the heart has been much agitated, the wavy inspiration sound has sometimes been heard mostly or entirely on the left side of the chest, and this has arisen possibly from pressure exercised by the heart and great vessels on the lung.

The waviness of phthisical inspiration is constant; that of nervousness is more or less inconstant or variable, and is reduced during periods of tranquillity.

Instead of the sound of inspiration in phthisis being wavy as described, it not unfrequently is observed to be *divided* into two or three distinct and completely separate parts. This has been noticed by writers, and is described as divided respiration. I have very frequently heard it in cases of lung heavily laden with tubercle, while the opposite lung has been healthy; but I have also heard it by no means rarely in lung far advanced in the first stage of phthisis, while the other lung has been the seat of cavities, and has indeed become almost useless as an aerating organ. If we would represent divided inspiration sound by a line, it would take this form: — . . . — . . . — . The blank or dotted parts represent the intervals. These intervals are generally about equal in duration with the separate parts of the sound.

The intervals, however, vary in duration, as do indeed the separate parts of the sound. This divided condition of the inspiratory sound is due to the same physical condition of the lung, which gives rise to the undulatory or rising and falling inspiratory sound in phthisis, viz. to the presence of an undue resistance to the in-passing columns of air; but in this case the obstacle is more complete, and, instead of simply somewhat checking or reducing the movement, puts an absolute stop to it, until the increasing and accumulating force of the inspiratory efforts overcomes the resistance, and draws in the air again, sometimes with an additional velocity, giving rise again to an augmented sound, i. e. augmented compared with the first part of the inspiratory sound. The divided sound is more frequently associated with tubercles than the undulatory or rising and falling sound, and is more seldom due to nervous action. But I have no doubt whatever that a divided inspiratory sound does not necessarily indicate either the presence of tubercles or of solidification from any cause. It is occasionally due to thickening of the mucous coats of the tubules of the lobules, and to an adhesive condition of their walls. The column of air enters so far; it is stopped by an adhering condition of the tubules; sound is suspended; with the accumulating force the adhering walls of the tubules are separated, air passes on, emitting its sound; the tubules collapse again, and, adhering, sound is suspended; the tubules are again forced open, the air is urged forward, and sound is emitted once more. An illustration of the division of a sound, uniform and continuous in health, by the operation of a cause such as I have described, occurs to me and seems worthy of notice here. During the presence of a congested and irritable state of the mucous membrane of the nostrils from an attack of catarrh, I have frequently listened to the sound of inspiration through the nostrils, and I have frequently observed that the sound has been divided into separate parts. When the sound has been suspended, I have felt the opposite sides of the nostrils to adhere; when the sound has returned, and it has done so suddenly, I have felt the sides to separate, and at the same time I have heard a clicking or separating bruit. The differential stethoscope, both in respect of undulating and divided inspiration sounds, gives very satisfactory results. The undulating or divided character of inspiration sound at one point is satisfactorily contrasted with the continuous inspiration sound in another part, by successive experiments. These abnormal inspiratory sounds in one part are readily compared with sounds approaching them in another part. When the differential stethoscope is simultaneously employed with its two cups respectively applied over the seat of these abnormal sounds and over the seat of healthy respiration sound, the two sounds, the healthy and the unhealthy, are heard separately through the ears respectively connected with them, and thus the mind of the auscultator is strongly and remarkably impressed with the difference of the two inspiratory sounds of the two parts under examination.

The wavy and the divided inspiratory sounds have sometimes been designated jerky. The divided sound is more frequently the subject of the quality implied. The jerky sound is loud, and reaches the ear in successive jerks. It is not uncommonly associated with phthisis, but is frequently the associate of mere nervous disorders.

CHAP. V.

FIRST STAGE: AUSCULTATION—*continued.*

Expiration: Loudness, Coarseness, Prolongation. — Prolongation of compensatory Respiration. — Associated Sounds. — Mechanism. — Differential Stethoscope. — Hydrostatic Pneumatoscope. — Protracted uno-aural Audition. —Curious Results from differential Stethoscope, with inspiratory and expiratory Sounds.—Restriction and Alternation of Sounds.—Want of acoustic Symmetry from other Causes. —Expiration of other Diseases. — Respiratory Interval.

The expiratory sound of vesicular respiration is very early affected in phthisis, and it speaks with a force nearly equal to that of inspiration, in reference to the disease, and the early stage, being regarded with more force than the visible movements of the chest, the vocal fremitus or resonance, or the percussion note. The partial occupation of a few vesicles in some few lobules of the apex of a lung by tubercular corpuscles, may not sensibly affect the expiratory sound, but I am convinced, that if the tubercular deposition be such as sensibly to increase the weight of a portion of the lung, to reduce its power of contractility, to press unduly upon the terminal tubules of a few lobules, the sound will be materially modified, and that this modification, regarded in its combinations and deprivations, so to speak, will afford most valuable materials for deciding, at a very early period, on the presence or absence of phthisis.

The first morbid alteration in the vesicular expiratory bruit, which we observe in incipient phthisis, and perhaps, in not a few examples, the very first physical sign, is an increase of loudness or elevation. In healthy lung, the expiratory murmur is more feeble than the inspiratory, and is not audible without more attention than is required for the hearing of the inspiration sound. It is difficult to express in words degrees of loudness, but it may convey some idea of the comparative intensity of the two sounds, to say that there is not merely a shade of difference, but that the mind will readily admit that between them there may be several degrees. Were we to attempt to express by figures the loudness of healthy inspiration and expiration, 4 might be set down to represent inspiration, and 1 expiration, or if we employed symbols, the following might be held to be tolerably correct.

Inspiration.

Expiration.

In phthisis in the first stage, this order constantly tends to change. The inspiration sound is approached in loudness by the expiration sound. As the deposition of tubercle proceeds, we observe that the expiration sound becomes louder than the inspiration sound; and this latter sound, instead of being four times louder than the other, reaches in some cases only to a fourth part of the intensity of the expiration sound. The inspiration sound has lost, while the expiration sound has greatly gained, in intensity.

The expiratory bruit of incipient phthisis, thus strengthened, is heard at one apex, viz. that selected for the deposition of tubercle, sometimes, rather rarely, at both, when, as in some cases, chiefly those in which a strong tendency to phthisis is made out, both lungs are found very early implicated. This loudness of expiration sound, may be confounded with a certain loudness of expiration which attends the puerile respiration of over-dilated, over-working healthy lung in phthisis; but the length of the preceding inspirations, and the full resonance on percussion, will serve to distinguish this form of increased loudness from the former. A certain loudness, following temporarily excited respiration, resembles the loudness of phthisis, but an observation during tranquil breathing, will correct this source of error.

The intensified sound of expiration in phthisis, is characterised not merely by elevation, but by coarseness. It sometimes acquires a character of dividedness, so to speak, which varies much in degree. In its lower degrees the interrupted expiration sound of phthisis, partakes of the character of a fine crumpling. A coarse crumpling, like that of coarse materials, and with greater intervals, is not unfrequently heard. When very fine, the interruption sound resembles the noise produced by pressing dry arrow-root powder with the finger, and I have frequently found this sign; but it is not uncommonly heard over the simply congested lung. The decided division of the expiration sound, such as the division of inspiration sound of which I have spoken, I have not often heard. I believe it to be extremely rare as a sign of phthisis. In dry bronchitis, I have not unfrequently found the expiration sound to be divided, but the sonorous and sibilant and almost musical rhonchi which accompany it, serve clearly to denote its value. Besides, the extreme length of the expiration sound indicates its bronchial nature; the expiration of bronchitis being often five times the length of inspiration.

But the expiration sound in phthisis is not only louder than natural, it is liable to be prolonged, and that to a great extent, but less so than in bronchitis, and much less so than in asthma. The proportionate duration of the sounds is altered. The expiration from being only one fifth or one fourth the duration of inspiration, will frequently be found double the length of inspiration. At first the increase of duration is slight, but at an early period it will generally be found to be at least one half or one third the duration of inspiration; and in many cases at the first examination, the expiration has acquired a duration equal to that of inspiration. The prolongation of expiration in incipient phthisis is of course found at the apices, the favourite seats of the early deposition of tubercle. It is heard chiefly during the dry state of the tubercle, and ceases almost always on the lung softening or becoming excavated. But when the long vesicular respiration has ceased on the occurrence of these changes, in the apices, it may be heard at the middle or the base of the lung, where tubercle may now be depositing, or still retaining its crude condition.

While the prolongation of the expiration sound of phthisis may be disappearing on one side of the chest, from the occurrence of softening and excavation, a certain amount of prolongation belonging to compensatory hypertrophy of the opposite and untuberculated lung, may be becoming established, but the moist sounds, and the cavernous acoustic signs on the tuberculated side, and the full vesicular respiration and clear percussion, with the natural prominence of the parts, will assign to each side its respective physical condition, with great certainty.

The prolonged expiration sound of phthisis is frequently accompanied by certain other signs, to be described at a later period. The occasional moist crackle is one of these signs; and when the left lung is the seat of the disease, the whiff of the pulmonary and subclavian arteries at the second and third costal cartilages is another. The whiff is synchronous with the systole of the heart, and three of them are generally heard in succession, and at equal intervals, during each expiration sound. Sibilant and sonorous rhonchi are not uncommon, but they are generally not loud, and seldom much diffused.

The coarseness of the expiratory sound of phthisis, is due to the friction of the air with materials more solid and resisting than natural, and to the compression of the materials themselves, solid and resisting, and therefore such as are calculated to produce a coarser and louder bruit. The prolongation is due to the increased resistance which the air passing out encounters in a tissue more solid than usual, and such as is capable of retarding the action of the compressing powers of expiration, which in ordinary respiration are not strong, or likely to overcome at once material resistance. The ordinary powers employed in the expulsion of air from the lung are, the natural elasticity of the proper fibre of the pulmonary structures, and the tendency of the diaphragm to regain its relaxed condition and arched form, and of the ribs and sternum to fall away from those elevated positions which they had only temporarily gained by the exertion of muscular force. These, though influential powers in the expulsion of air in a state of health, are not such as to overcome at once the increased resistance found in tuberculated lung, and are precisely such as are likely to admit of a retardation, and under some circumstances, even a decided check, or interruption. The elasticity of the proper lung fibre, the elasticity of the diaphragm, and the elasticity and weight of the thoracic walls, may be likened to so many mechanical springs. In phthisis their action meets with unusual impediments, the same as springs which have become rusted or obstructed. The retardation and check which we observe to hold in respect of the expulsion of air, and it may be added also, of the ingress of air, in phthisis, is analogous to the check and impediments which we notice in the case of water trickling on an inclined and irregular surface.

The prolongation and coarseness of the expiration sound in phthisis, is made out satisfactorily by the ordinary wooden stethoscope. To compare the coarse respiration sound of the diseased part with the fine respiration sound of a healthy part, however, the instrument must be moved from one part to another, the head must be lifted, and then re-adjusted to the stethoscope. In examining the comparative duration of the inspiration and the expiration sounds of the same part, no re-adjustment of the instrument is required, so that little room for error exists in taking this observation.

The removal of the stethoscope from one part to another in comparing the coarseness or loudness of the expiration of one part with those of another, offers certain obstacles to a very exact appreciation of differences. Time is lost, extraneous impressions are made upon the mind, and time is given for extremely fine impressions to fade away. Muscular efforts of the neck, and often of the trunk, are made before the head of the auscultator can be duly adjusted, and movements of the patient, and even mere conversation, may, and do often, occur to cause the impression to be weakened, and to vitiate the comparison of one sound with another.

This evil is very effectually avoided by the employment of my differential stethoscope. The expiratory sound of incipient phthisis, is generally only an exaggeration of the healthy sound, and as it is an acoustic law, that the exaggerated sound carried into one ear eclipses, so to speak, or sensorially destroys, the weaker sound carried at the same time into the other ear, the expiratory sound in phthisis when coarse and prolonged is heard, or seems to the mind of the auscultator to be heard, through that ear only connected with the diseased portion of the lung, and not at all through that ear connected with the healthy lung. And this holds, although the sound of the healthy lung is distinctly heard when one ear only is employed upon it, as may be proved by lifting the instrument from the diseased part, for at this moment the healthy expiration sound may be heard, and through the ear which previously seemed to take no part in the act of audition. This forms an absolute and complete test of the coarseness and loudness of the expiration sound of one part of the lung over that of another. If there exist a material difference in the coarseness or loudness of the expiration sounds of two parts of the lung, and yet it may be so slight as almost to defy detection by the use of the ordinary stethoscope, this absolute proof may be at once procured by employing the differential stethoscope. This restriction of hearing to one ear, forms the test which I have called the uno-aural test, which to the auscultator, and more particularly the less experienced, is I believe extremely valuable.

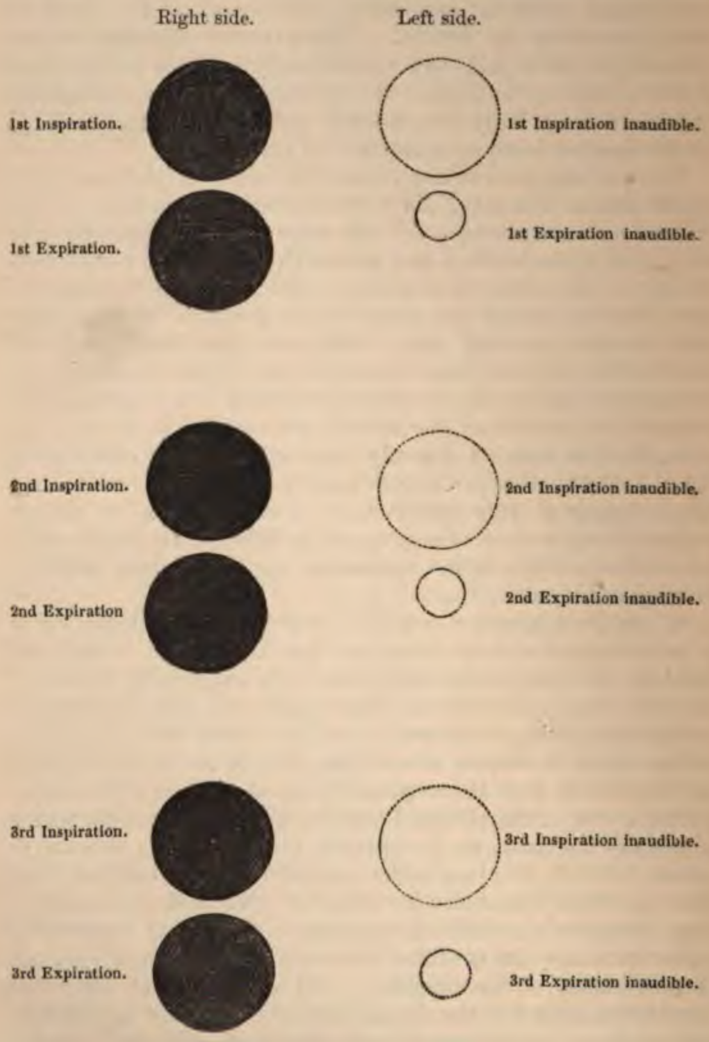
When the superiority in respect of loudness or coarseness in one part is not so great as to produce sensorial destruction, so to speak, of the same sound from another part, the simultaneous employment of the two sound collectors will still serve to show the difference, for the sound will be heard louder in one ear than in the other. One ear will appear to be more engaged in the act of audition than the other. Not only the ear, but the corresponding side of the head is speedily acted upon. But it has been found that, with auscultators using the differential stethoscope for the first time, a certain degree of doubt or confusion is experienced when both ears are simultaneously employed, and when the degree of difference is not such as to produce the absolute test of uno-aural hearing. When this is the case, the evil is obviated by making separate examinations of different parts in succession. This is effected by making an observation of one part with one ear, and immediately after an independent examination of another part, in this manner. The cups, instead of being applied at the same moment, are applied in succession. As very little time is lost in successive trials, and as the head and ear of the auscultator are not moved, and as the patient is not required to change his position in the slightest degree, great facilities are obtained for correct comparison or contrast. A very small degree of difference is thus readily appreciated.

The prolongation of expiration in tuberculated lung may be well ascertained by auscultation with the wooden stethoscope, taking the duration of the inspiratory sound as a standard. For the exact and absolute measurement of time, a watch may be placed before the eye, while the ear is listening. The space travelled over by the second hand during the two acts, indicates their respective duration, but the comparative duration of the two movements is perhaps better exhibited and demonstrated by the employment of my pneumatoscope or breathing measurer, to be hereafter described. When this is applied in incipient phthisis, it is found that the ascent of the column of liquid is seen to be more rapid than the descent of the column of water which corresponds with the expiration, the reverse of the order of the movements in health. The extreme slowness of the descent of the liquid very satisfactorily conveys to the mind of the observer, the degree of impediment to the expiration, and much more fully than merely measuring space travelled by the second hand over the dial of the watch.

The prolongation of the expiration sound of phthisis in its crude tubercular stage, is well exhibited by means of the differential stethoscope. Both cups being simultaneously employed upon healthy and unhealthy parts, the sound continues to be heard in the ear connected with the morbid part after the sound has ceased to be heard in the ear connected with the sound part. This test of protracted audition, is afforded only in those examples of disease in which the intensity of the sound of the diseased part is not sufficient to sensorially annihilate the sound coming from the healthy part, in the manner already referred to. The observation thus made of the prolonged expiration sound, has to my mind appeared very satisfactory, and I confess to always experiencing a sense of enjoyment in establishing its presence by evidence which to me appears so very conclusive, and free from possible error.

When the expiration sound of that portion of lung which is tuberculated carried to one ear has become so coarse and loud as to sensorially annihilate the expiration sound of healthy lung conveyed to the other ear, the differential stethoscope being employed, it will be found that the inspiration sound in respect of audition, is very commonly affected in its relation with the expiration sound. Thus if the inspiration sound of the diseased side be strong and rough, which is usually the case, in the earlier periods of the deposit of crude tubercle, the inspiration sound is heard only on that side on which the expiration sound is perceived, hence in this case, the whole sounds of respiration, including inspiration and expiration, are confined to one side of the chest, viz. the diseased side. (See diagram.) If on the other hand the inspiration sound of the diseased side be defective and feeble, and without the adventitious bruits of rhonchi and crepiti, which is more particularly liable to occur at the advanced

Tuberculated right side, with rough loud inspiration and coarse prolonged expiration. The left side healthy. The inspiration and expiration sounds heard only on the diseased side, the differential stethoscope being employed simultaneously on both sides. The dotted figures represent the natural sounds as heard with the ordinary stethoscope.


Right side.
Left side.
1st Inspiration.
1st Inspiration inaudible.
1st Expiration.
1st Expiration inaudible.
2nd Inspiration.
2nd Inspiration inaudible.
2nd Expiration
2nd Expiration inaudible.
3rd Inspiration.
3rd Inspiration inaudible.
3rd Expiration.
3rd Expiration inaudible.

stage of crude tubercle, when it has massed and, as it were, pressed out the vesicular structure of the lung, the inspiration sound is heard only on the healthy side, and hence in such a case we have inspiration sound only on one side, and expiration sound only on the other or diseased side, which really form very curious and remarkable acoustic phenomena. There is established in this latter case, what may not incorrectly be called a sensorial oscillation of the respiratory sounds from one side or part of the chest to the other. The inspiration sound is first heard on one side, say upon the right or the healthy side, and the expiration sound is heard upon the other or the left or unhealthy side. The inspiration sound is heard through the one ear, and the expiration sound through the other, as, with the differential stethoscope in use, one ear is connected with the healthy and the other ear with the unhealthy lung. (See next diagram.)

The oscillatory respiration of which I have thus given a description has been observed by me in many hundred examples of phthisis, but as far as I can remember, in no other form of disease. The characters of the respiration are so pronounced as to be almost insusceptible of being mistaken for others or of being overlooked, and are therefore of the greatest value. But it is to be remarked that the oscillatory respiration sounds are not confined to the first stage of phthisis. I have observed these auditory phenomena in numerous cases in which cavities have been present. This has taken place when, having full eclipsing inspiration, so to speak, on the healthy side, the inspiration on the cavity side has been faint and weakly pronounced, and when, as sometimes happens, an impediment has been offered to the exit of the air from the cavity, friction has been incurred, and loud sawing or blowing tubular bruits have been produced, eclipsing the expiratory sound of the healthy lung. But the stage of the disease is in almost every case indicated by the character of the expiration, being very abnormal and by the other usual, physical attendants, in respect of shape, percussion, voice, &c.

In estimating the value of greater loudness and fullness and prolongation of vesicular respiration sound on one side of the chest, it is important to bear in mind two prominent facts already referred to. The first is, that in general the inspiratory sound is equal, or nearly equal, on both sides of the chest in most persons in health. The second, which is a comparatively minor one, yet an important one, is this, the vesicular sound in a number of persons, and not a very small

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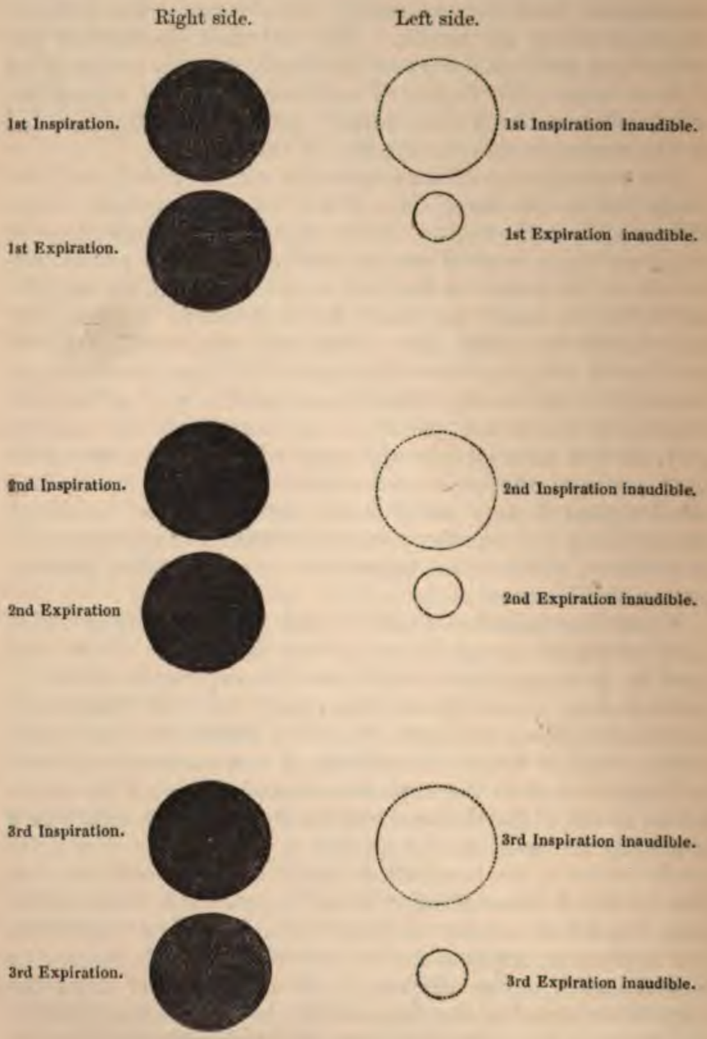
Right side.
Left side.
1st Inspiration.
1st Inspiration inaudible.
1st Expiration.
1st Expiration inaudible.
2nd Inspiration.
2nd Inspiration inaudible.
2nd Expiration
2nd Expiration inaudible.
3rd Inspiration.
3rd Inspiration inaudible.
3rd Expiration.
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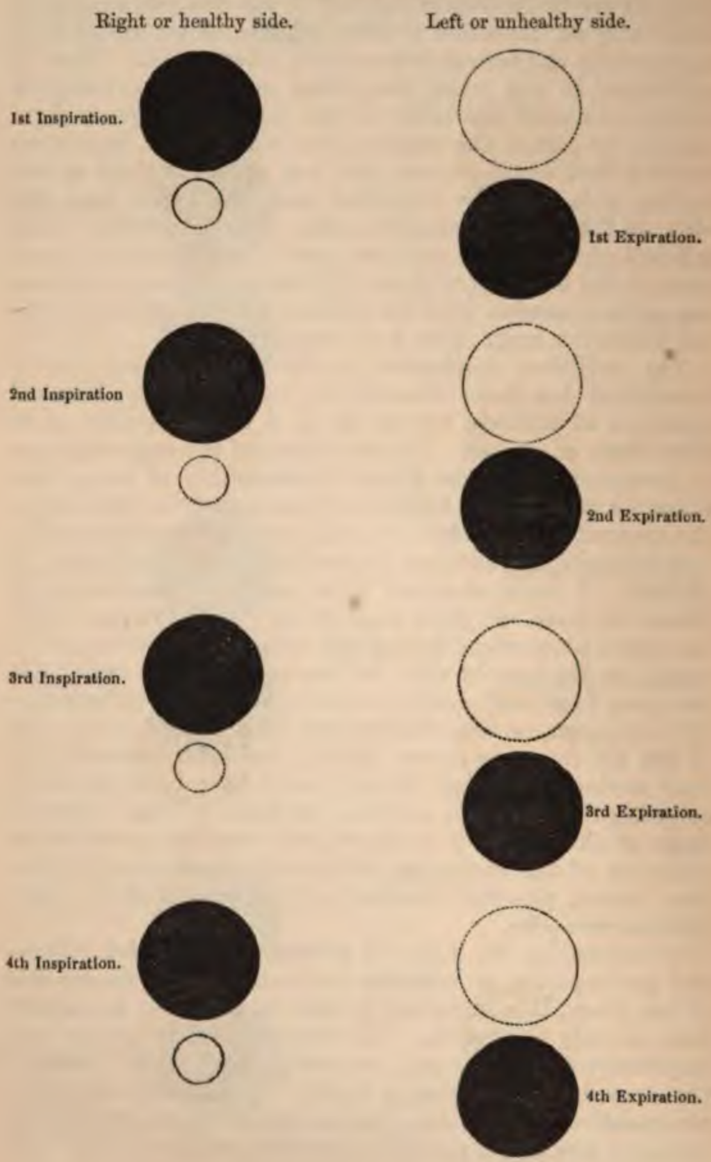
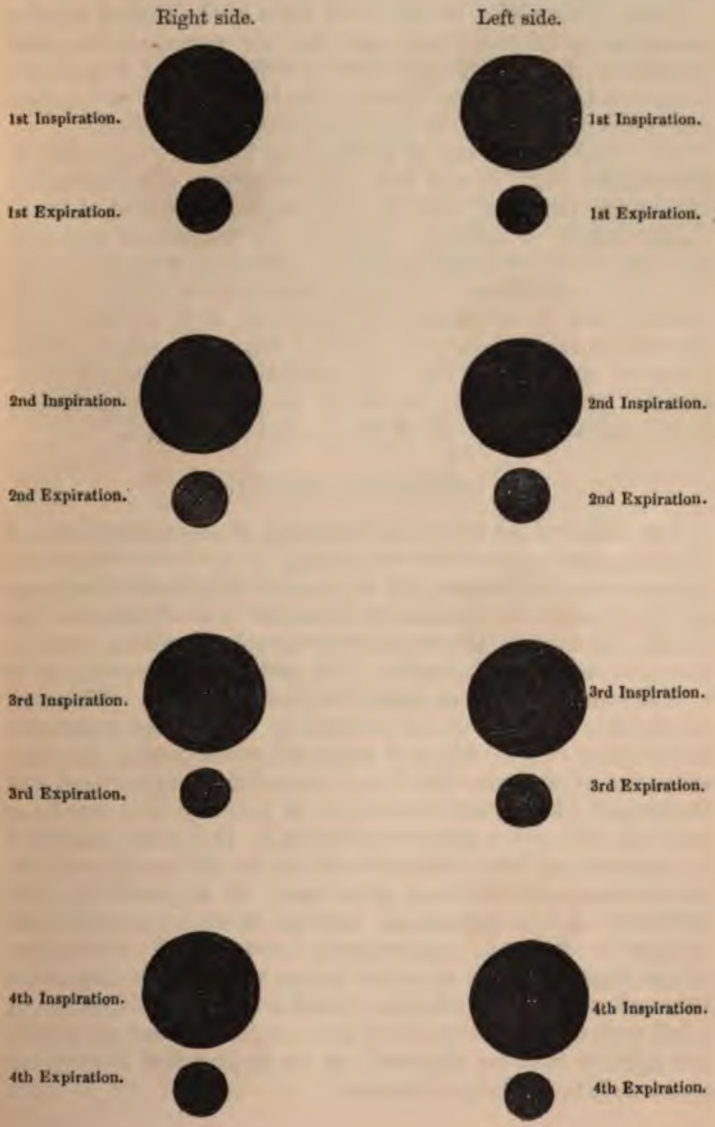
Oscillating or alternating respiration of pulmonary consumption.

Only the black circles represent heard sound.



HEALTHY RESPIRATION.

The following diagram illustrating healthy respiratory sounds, the differential stethoscope being employed, will serve as a standard for comparison. Sounds are heard on both sides.



minority, is certainly fuller and louder and more protracted on the left than on the right side of the chest. For years I have met with examples of this disparity. It is therefore necessary to regard this fact in solving harsh respiration sound on the left.

Great deformities of the bone walls of the thorax causing compression of the lungs and the air passages, we must remember, frequently give rise to deficiency of respiratory sounds at the compressed part of the lung, and to excess from compensatory respiration at those parts that are free.

The long expiration of phthisis, in its first stage, may be confounded with, 1, the fine long cavernous dry respiration of some cavities; 2, with the long expiration sound of bronchitis, and 3, of asthma. Dullness on percussion and pectoriloquy denote the first condition; diffusion of rhonchi, some dyspnœa, and absence of rapid deterioration of health, the second; and great paroxysmal dyspnœa, with wheezing, and clear percussion sound, the third. We must bear in mind, however, that bronchitis and phthisis are frequently combined. The expiratory sound is very generally prolonged in all obstructive disease of the trachea and larynx.

RESPIRATORY INTERVAL.

The interval between the cessation of one expiration and the commencement of the succeeding inspiration is shorter in phthisis than in health. At any period of even the first stage of this disease, the interval is observed to be shortened. In health, the interval during calm respiration is about equal in duration to the expiration. In phthisis, however, it is reduced materially, and may be altogether absent. This sign of phthisis becomes more marked as the disease progresses to its later stages, when it attains its maximum. In some examples of phthisis, this sign is one of the very earliest, and is noticed before the expiration is sensibly prolonged, or percussion becomes unequivocally dull. It is most remarked in acute cases, when the circulation is quickened, and the temperature of the face and hands is augmented. The reduction of the respiratory interval, however, occurs in all diseases in which the respiration is hurried, or the circulation is quickened, and is therefore a sign to which no diagnostic value attaches. Nevertheless, it is deserving of this notice in a full review of the respiratory acts of phthisis, but with this, the subject may be regarded, so far as practical objects are concerned, to be fully exhausted.

CHAP. VI.

FIRST STAGE: AUSCULTATION—*continued.*

The vesicular Sounds of the First Stage vary much according to the various physical Conditions of the diseased Lung.

THE various forms of departure from the normal conditions of the vesicular sounds just described, and from their periods and intervals, although present during some part of the first stage of phthisis, if we except that generally very short time during the deposition of tubercle in extremely fine points not larger than pin-heads, and only thinly scattered over one apex, or even throughout a considerable portion of the lung. But the extent to which these various acoustic departures form the healthy state varies to a very great degree at different periods of the first stage, according to the extent of organic change, and to the various morbid physical conditions of the diseased lung itself. Though we speak of phthisis in its first stage, and though we must have in this stage one condition always present, viz. crude tubercle corpuscles, either in defined masses, or infiltrated throughout the tissue, forming ever a great character in common; and though this character is so important, in the great proportion of examples of phthisis which we see, as to form a most useful and broad obvious line of demarcation from phthisis in its second and third stages, still the practical physician has no alternative but to confess that, in taking a full survey of the first stage, the presence of tubercle in the condition of consistent deposit or infiltrated tubercle without softening and disintegration of the surrounding lung structure, is but a highly imperfect exponent of the actual physical condition of the lung. For we find differences in the actual physical characters, in respect of weight, consistence, elasticity, inflatability, liquid infiltration, conduct in respect of sound both in its origination and transmission, of lung at different periods of the first stage of phthisis, in different examples of the disease, so great as to separate the specimens widely asunder; and even in some cases to force upon us the conviction that more difference exists between these examples of the first stage, than is to be found between other cases, some of which belong to the first, some to the second, and some to the third stage. For instance, we may have in the first stage great consolidation, in the second, very partial softening, and in the third, a very small quiet cavity.

It is unnecessary in this place, to describe fully the very different physical conditions of lung, which we find in different examples of phthisis in the first stage, for these will be treated of in their proper place; but it may be useful at this moment to enforce the principle that we cannot have the same acoustic results from lung having only a few scattered minute pin-head like spots or points of tubercle throughout, giving a scarcely sensible addition to its weight and resistance, and from lung which we often find still only in the first stage of the disease, rendered obviously to the eye fuller and rounder, non-collapsing under the weight of the atmosphere; greatly increased in weight, gorged with blood, scantily inflated with air, pressing effectually upon even the larger bronchi and blood-vessels, and densely studded with large masses of yellow tubercle, the size of garden peas, filling the finer tubules of the lungs in cylindrical forms and imparting to the incised surface as much of a tubercular and solid as a vesicular aspect.

Such differences in the coarser physical conditions of the lung lead to differences in the acoustic properties of the lungs, and we therefore look in vain for precisely the same characters of vesicular respiration in all examples of the first stage of phthisis. The roughness and coarseness of respiration sounds will be faint at first, and will increase for some time with the progressive deposition of tubercle. This sign will then be succeeded by deficiency of sounds, or be replaced by an entirely new sound, viz. bronchial or pipe breathing sound, as in the progress of the disease the vesicular structure of the lungs is obliterated or rendered uninflatable, and the inspired and expired air passes along, merely through constricted and narrowed bronchial pipes, and fails to penetrate cellular structure and to produce that healthy vesicular sound which attends this act. Obliterated bronchial tubes, compressed by masses of tubercle and the presence of liquid secretion in still pervious tubes, cannot fail to impress new characters, such as sibilant and sonorous rhonchi, upon the respiration sounds; and such conditions, rare in the first period of the first stage, are common before the commencement of the second. Constricted and congested pipes will succeed in drowning or eclipsing the minor sounds of harsh, rather harsh, feeble, and deficient inspiratory and coarse expiratory bruits.

CHAP. VII.

FIRST STAGE: AUSCULTATION—*continued.*

Bronchnœa Sounds. — Localities. — In various Diseases. — Rarity in acute Phthisis. — Features in different Stages. — Heard through differential Stethoscope. — Curious acoustic Results. — Mechanism of Sounds. — Conduct during first Stage.

When in the first stage of phthisis the amount of tubercle has become so great as to fill up most of the vesicles of some considerable part of a lobe, or by means of pressure to render them or many of them uninflatable, and when the bronchial tubes of larger or quill-like size are yet left patent and free enough to be filled with air during the act of inspiration, then we have a bruit different from that of vesicular respiration, and resembling the bruit produced by air passing quickly along pipes of the size indicated. This kind of respiration sound is called bronchial breathing sound. It is usually found at an advanced period of the first stage, follows the period of rough and deficient respiration sound, and precedes the moist crepitation of the second stage of the disease. The sound seems to proceed from tubes offering no fine or numerous points for friction such as are presented by the vesicles and terminal bronchi. It seems to be of larger volume than rough vesicular breathing. It is wanting or deficient in multiplied or rustling character. The inspiratory act presents it, but it generally attends likewise the expiratory function. The sound is generally that of air passing with tolerable ease and at a moderate rate, but it occasionally becomes quick, noisy, and whiffing, as if the current were quickened and friction were increased by means of the pipe calibre being reduced. This character of whiffing is noticed when, beyond a dense mass of lung, a portion of lung is still inflatable, which is supplied by bronchi passing through or near the morbid mass. This tubular breathing sound, as it is sometimes called when appertaining to phthisis in the first stage, is generally located in one apex, but it is frequently found at both, and obviously for this reason, that it corresponds to a comparatively advanced period of the disease, when it is usual to find both lungs implicated. It is readily found above the clavicles and immediately under them. It is most decisive when found near the humeral extremities of these bones. I have frequently found this form of breathing sound more pronounced during expiration than during inspiration. Its phthisical origin is strengthened, i. e. rendered more probable, when it is associated with dullness on percussion, increased vocal fremitus, particularly if on the left side; by great distinctness and strength of the thoracic voice, by a degree of flattening of the chest, occasional hoarseness of the oral voice, and by its (pipe sound) absence at the base and lateral regions, except in very advanced cases. When heard at the base and lateral region in a marked manner, it may be dependent upon hepatisation, the result of intercurrent inflammation, but this will be revealed by the history of the case and the dull percussion note. This sign may be dependent upon partial pressure on the bronchi from aneurismal tumours of the aorta, mediastinal tumours chiefly cancerous, and from cancer of the lung itself, generally connected with cancer of the mediastinum; but the limited area of dullness, the presence of dyspnœa to excess, the absence of the characteristic sputa of phthisis, and the signs of obstructed circulation, such as dropsy, varicose veins of chest and neck, will suffice to justify the exclusion of phthisis, and lead to a correct diagnosis.

Bronchial respiration sound, though usually present during the latter portion of the first stage of phthisis, and particularly in the chronic form of the disease, may not be recognised at all in some cases. The examples of the disease, in which we most frequently fail to find bronchial respiration or bronchnœa, as I propose to call it, are those in which the rapid deposition of miliary or small tubercles is early followed by ramollisement of the structure of the lung, and with copious secretion denoted by much moist large crepitation, the sounds of which obscure the sound of bronchnœa. The signs of the second stage, and even the third stage, so soon succeed to those of deposit in some acute cases, that time is not afforded for the establishment of a separate marked period of bronchnœa, of any but the shortest duration.

Though bronchnœa bruits are common attendants upon the later periods of the first stage of the disease, they are heard occasionally in the second and third, and care must be taken to ascertain to what stage they appertain, and this may be done with certainty in nearly every example.

Bronchnœa bruits may be heard in the second stage when the moist crepitation and fine moist cavernulous sounds are faint, and when the bronchial tubes remain patent and free from accumulating secretions or exudations, when the respiration is forcibly carried on, and when the lung structure is more than usually dense and heavy, and has thus become a cause of increased resonance, and is free from vesicular respiration. When the moist sounds abate from temporary causes checking secretion, bronchnœa sounds are heard for a time, but in a few hours, or in a few days, the moist sounds return and these sensorially silence the bronchnœa bruits. Sometimes the second stage is arrested, the progress of softening no longer proceeds, the secretions are permanently checked, the loud moist large crepitation departs or becomes rare and feeble, and the lung previously softening becomes firmer in structure. Feeble pipe respiration may be then established and become permanent. These facts should serve to guard against our mistaking the bronchnœa sound of the first for that of the second stage of the disease.

The third stage of phthisis may restore bronchnœa sounds or produce them for the first time. The moist crepitation and fine cavernulous sounds of the second stage having ceased, by the expulsion of the broken down lung, and the formation of a silent cavity free from secretion or friction or creaking sounds, the proper pipe or bronchnœa bruits may be re-established. This is by no means an uncommon occurrence; and though bronchnœa sounds are more especially the sounds of the first stage of phthisis, they are to be regarded as the not unfrequent attendants of that disease in its third stage when the conditions of the cavity or cavities are such as have been referred to. The finest example, perhaps, of bronchnœa respiration sound which I have lately had, was one in a young lady (C. H.) I lately examined, having a large cavity on the left side, dry and silent. In this case the respiration, including inspiration and expiration, was loud, but of short duration. The sound was that of air passing through a tube half an inch in diameter. The inspiration was continuous and uniform, while the expiration was distinctly divided into two parts. The cavity was denoted unequivocally alike by the history of the case, the presence of superficial articulating, non-vibratory pectoriloquy, the retraction of the costal cartilages and the intercostal spaces, and the short dull sound of percussion. By such accompaniments we are enabled to distinguish the bronchnœa sounds of the third stage from those of the first stage of phthisis, with which we are now more particularly concerned.

The bronchnœa bruits of phthisis are satisfactorily made out by means of the ordinary stethoscope. But the employment of the differential stethoscope will be found highly useful in enforcing, as it were, at once upon the mind of the auscultator, the presence of two very different conditions of lung on the two sides of the chest when the disease is confined to one part, as is usual at the first period of the malady. The bronchnœa sounds in the first stage being usually feeble, short, and defective, they make very little impression on the ear, when this is conveyed to one ear only, and this deficiency is contrasted with the full vesicular, rustling, noisy respiration sound of healthy lung conveyed to the other ear, or it may be the same ear, by an immediately succeeding observation. To be perhaps more explicit, it may be said that the successive auscultation of the healthy and the unhealthy lung by means of this instrument, which virtually takes observations from two parts and with great ease for the two ears respectively, affords great advantages for the mind discovering the difference between the character and extent of the respiratory sounds of the two parts. And it is to be observed, that a more satisfactory perception of the differences which exist is thus obtained than by the successive application of the wooden stethoscope, as has been already observed, and as will be further dwelt upon when the properties of this instrument offer themselves for special notice at a subsequent part of this work.

The bronchnœa bruits of the first stage of phthisis, located on one side, are usually feeble and defective as compared with the respiration sound of healthy lung upon the opposite side, more particularly so when, as generally happens, the respiration on this side has become puerile or compensatory. If the bronchnœa bruits are characterised more by the absence of the fine friction sounds of vesicular respiration, and less by the adventitious character of blowing or loud whiffing, the respiration sound is then remarkable more for negative than for positive characters. It is rather the ordinary respiration sound deprived of much of its fine friction or rustling character, and is therefore very much a form of ordinary respiration sound, minus a certain quality. This naturally prepares us for the following important diagnostic fact, valuable at once in auscultation, and curious as an auditory phenomenon.

When the two ears are separately connected by means of the differential stethoscope, with a tuberculated bronchial breathing lung, such as is described above, and with a healthy lung at the same moment, the vesicular full respiration of the healthy side is recognised through the ear connected with it, and the bronchial defective ill-formed respiration sound of the unhealthy lung is not at all perceived through the ear connected with *it*. The ear connected with the bronchnœa lung is deaf, as it were, while the other ear connected with the vesicular breathing lung is rendered particularly alive to the sounds conveyed to it. It is a curious fact, and one which shall be explained hereafter, that while the ear employed by means of the stethoscope upon the bronchnœa lung, carries no impression whatever of the peculiar breathing of the part, its employment in this way increases the sensation of vesicular respiration exclusively heard, as it were, through the other ear. The vesicular full respiration sounds conveyed to one ear eclipse simple, quiet bronchial respiration sounds conveyed simultaneously to the other ear in the same manner, and as effectually as full vesicular respiration sound eclipses defective vesicular respiration sound, as has been already described. To ascertain whether the respiration sounds which are eclipsed be defective vesicular respiration sounds, or quiet non-blowing or whiffing bronchial bruits, is a matter of the greatest ease. We have simply to take an observation of the unhealthy part with one ear, and with one limb of the stethoscope. The vesicular or the bronchial character is then satisfactorily ascertained by this single and separate act of uno-aural audition. When, however, the bronchial respiration assumes a blowing, loud, whiffing character, which it occasionally does, much more frequently it is true, in the third stage of phthisis than in the first, it effectually eclipses the vesicular respiration of the sound lung if this be not particularly loud. The loud sound of blowing tubular respiration heard through one ear, and the absence of sound in the other ear, convince the mind at once that a very serious difference in the conditions of the two lungs exists. The auscultator being thus unmistakably assured of this, proceeds narrowly to detect the precise character of the two sounds respectively, and satisfactorily determines the precise physical conditions of the parts, and he does this by now examining them separately or in succession.

It occasionally happens that the inspiration of bronchnœa respiration is loud and blowing, while the expiration sound is feeble and indeterminate. In this case, when the differential stethoscope is simultaneously employed for the two ears on healthy and unhealthy lung respectively, the bronchial breathing only is heard in one ear and the vesicular respiration is heard in the other. Now we have bronchial inspiration sound on one side, oscillating, as it were, or alternating, with vesicular expiration sound on the other. This alternation of sound obtains occasionally, in the first stage of phthisis, but it is much more rare than oscillation, so to speak, of bronchial expiration sound on one side, with vesicular inspiration sound on the other. This is, however, more frequently found in phthisis in its third stage, marked by dry cavities, having bronchial outlets offering resistance, and with puerile breathing lung on the opposite side. When this form of oscillation of sound from one side to another is perceived, the first stage of phthisis has generally been long passed, the third has often arrived, and therefore this point may more properly be dwelt upon at a later period than at the present moment.

The mechanism of bronchial respiration sounds must be obvious from the description which has just been given of them. However, it may be well to say, that the sounds are produced by the motion of air passing in and out of tubes; bronchial tubes, varying in size from a quill to the little finger. Friction is produced, and the tubes and the passing air are thrown into sonorous undulations. The pressure exerted upon the tubes by the surrounding solid tubercle and condensed pulmonary structure aids in the production of friction. The rapidity and force of the respiratory acts, now considerably augmented, further tend to the induction of friction, and therefore of sound. When air passes along a tube of the calibre referred to, with freedom and ease, the tubular sound will be recognised, but it will be destitute of the blowing character which we have said bronchnœa sometimes possesses. It is when the tubes are constricted or pressed upon to some considerable extent, and when the air is passed along with force, that we have constriction and harsh blowing sounds. When tubes which are situated as we have above described become free from constriction and pressure, as may be the case on the formation of cavities, this constrictive character of sound ceases. When tubes which have been emitting sounds become altogether occluded by increasing pressure, or by the formation of plugs of lymph, and mucus, and blood, tubular sounds cease altogether. If the force of air passing along be very slight, the friction may be too feeble to produce sufficiently rapid vibrations in the solids for the induction of sound. A firm tube surrounded by firm heavy structure will be indisposed to vibrate with a slight force. But on the other hand, firm structure will serve well to communicate the actually produced sound to the thoracic walls. Condensed lung structure has long been believed to conduct in a superior manner, bronchial sounds to the walls of the thorax, yet there is no doubt whatever that if weight and firmness be very great in proportion to the sound-producing movements, then they will prove unfavourable to sound, not only by a deficiency of conducting power, but by operating against the production or origination of sound. I have found by experiment that vesicular lung conducts sound about as well as solid lung. A tube once thrown into sonorous vibrations will transmit sound better to solid than to vesicular lung, for solids transmit to solids better than to aeriform bodies. Solid lung again in vibration will transmit sound to the thoracic walls better than vesicular lung, for solids accept sound better from solids than from aeriform bodies. Although I believe the solid conduction to the surface aids in the audition of bronchnœa sounds, I am of opinion that the abolition of vesicular respiration sound is the great cause of our hearing this acoustic sign. We have seen that vesicular bruits can eclipse bronchial sounds.

In determining whether tubular bronchial or brochnœa sounds are unhealthy, and may be the result and evidence of phthisis, we are to remember that the locality of the sounds is as essential to the solving of the problem as the sounds themselves. What in one part of the thorax is an unmistakable sign of disease, and that is presumptive of the presence of tubercle and consolidated lung, in another part is perfectly normal and of no account whatever as evidence of disease of any kind. In the interscapular regions bronchial respiration sounds are normal, while, on the other hand, in the supra-clavicular and infra-clavicular regions they are highly morbid and very suggestive of pulmonary consumption. At the scapular regions these sounds are frequently heard, but less so in the first stage of phthisis than in the two following ones, and in simple hepatisation. Here they are abnormal.

When tubular respiration sounds have become established in the first stage of phthisis, they almost invariably remain for some considerable time. It does occasionally happen that these sounds disappear, and are succeeded by a quasi-vesicular sound when the patient is improving; but this occurs chiefly when there has been present some inflammatory consolidation. When softening with moist sounds in abundance occurs, tubular respiration sound frequently becomes inaudible, the former totally masking it.

CHAP. VIII.

FIRST STAGE: AUSCULTATION — *continued.*

Sonorous and sibilant Rhonchi. — Dry and humid Crackle or Clicking. — Humming. — Buzzing. — Arrowroot Crepitation. — Wool or Yarn tearing Sound.—Rolling Sound.—Pleural Sounds.—Crepitation, fine and medium.

SONOROUS AND SIBILANT RHONCHI.—It has been usual amongst authors, in treating of pulmonary consumption, to omit rhonchi as signs of phthisis; and if incidentally mentioned, these important and very common sounds in the course of this disease have been referred to rather as evidence of the presence of bronchitis in contra-distinction to phthisis, and even as tolerably good presumptions of the non-phthisical nature of the malady of the patient who has been the subject of them. From my own experience I would say that these sounds have been erroneously estimated. Far from their presence indicating the absence of phthisis and the presence of mere bronchial affections, they are commonly, if not very commonly, the products of the former malady, and may be rendered valuable aids in the detection of this disease, if rightly understood. It is very true that these sounds are much more constant signs of bronchitis than of phthisis; that they are, in short, more the signs of bronchial than of pulmonary disease, in the same way as harsh and deficient vesicular inspiration and coarse long expiration are more the signs of phthisis than of any other disease.

Few examples of phthisis pass through the first stage without the development of these signs. But they differ in several respects from the same signs in mere bronchitis.

The sonorous rhonchus is a small tube sound, the tube being about the size of a goose quill. Its characters seems to indicate a degree of constriction during the passage of air, retarding this fluid, exciting friction, and throwing the tube and air into prolonged musical vibrations. The air seems to pass through the tube at a moderate rate. The constriction or narrowing of the tube depends generally upon congestion and thickening of the mucous membrane, and upon the presence of tenacious mucus in very moderate amount. The sibilant rhonchus is a finer sound; it is of higher pitch, and of shorter duration. It possesses a hissing character. This sound emanates from finer tubes than those that give out the sonorous rhonchus. The tubes here concerned are almost capillary and near the vesicular structure, and near the seat of the tubercle.

The sounds are heard for the most part during inspiration and expiration. Sometimes they are heard only during a forced inspiration. The sonorous rhonchus is frequently more loud during expiration than during inspiration. It then frequently takes on a "cooing" character, and is very prolonged.

The constriction or narrowing of the tubes, and the presence of dry tenacious mucus, are due in phthisis to the operation of the tubercle in the neighbouring air-cells. Irritative action spreads from the cells and terminal bronchi. A degree of vascular congestion, or even inflammatory action, is generally present.

These sounds when appertaining to phthisis, are seldom very marked in loudness or in continuity during an inspiration or an expiration, certainly for the most part much less so than in pure bronchitis. They frequently become developed during the space of a few inspirations, and then cease for a time, to return in a few hours or days, and to continue, it may be a very short time. A single comparatively short-lived sound will frequently be heard during an inspiratory act. After listening in vain for a rhonchus, suddenly a loud "snore" or hiss will be heard. But it is to be observed, that in some examples of phthisis in the first stage, it is true, fewer than in the second and third, and yet not very few, continuous loud and greatly diffused rhonchi are heard, and serve effectually to mask all other respiratory sounds, and even the sounds of the heart itself.

The locale of the rhonchi of phthisis in the first stage is much more limited and fixed than that of mere bronchitis. It is at the supra-clavicular region, the infra-clavicular region, and the mammary and lateral regions that these signs manifest themselves in the first stage. It is commonly only at the two first mentioned regions that these signs first appear. As the disease proceeds, these sounds, remaining at their original sites, slowly extend themselves to the last-mentioned regions. They are at first confined to one side of the chest, the unhealthy side, but as the deposition of tubercle progresses, and vascular congestion extends, they become audible on the other side also. When in the first stage of phthisis much deposition of tubercle has taken place, and some solidification and congestion of the base of the lung has become established, the rhonchi are generally found at the lower lateral and inferior dorsal regions, and they prove pretty continuous there.

A small amount of sonorous or sibilant rhonchus, even when occasional only, in the region of one clavicle, when the patient is declining in health and losing flesh without the ascertained presence of some other adequate cause, and if the patient be between the age of fifteen and forty-five years, may be regarded, by no means, as proof of tubercular deposition in the lung, but as highly suggestive of it. It may practically be useful and prudent to regard these sounds as proof, not of phthisis, but of probable phthisis, if such an expression — and it seems a common sense one — may be employed.

The rhonchi of phthisis tend to be stationary in the first stage, if the malady be not advancing rapidly; the rhonchi of acute bronchitis begin at the apex, and travel down to the base, leaving the upper parts as they reach the lower.

The rhonchi of phthisis in its acute form, even in the first stage are generally diffused over both sides of the chest; and, in this respect, the rhonchi of chronic or slow ordinary phthisis differ from those of acute pulmonary tuberculosis, and particularly of those examples complicating or following the exanthematous diseases.

DRY CLICKING SOUND. — A sound answering to this title, is of frequent occurrence in phthisis in its first stage. It resembles the sound which is produced by a thick film of butter placed between two plates, and ruptured by their separation. It may be imitated by placing butter or thick gum water at the open mouth of a quill, and by passing air through it. The material is thinned by the air, and forming into a quasi-membrane, ruptures. The rupture produces a sound like the sign under consideration. This sound is loudish, and occurs generally singly during the inspiration. Two or three may be heard during one inspiration. Its most common seat is above and below the clavicle, on one side, later on both. It tends to be converted into moist crepitation, signalising the advent of the second stage. In examples of phthisis becoming passive, and in which tubercles are drying up and becoming quiescent, this sound is lost.

The dry click has been held to be a very significant, serious, and weighty sign of phthisis, but while I acknowledge it to be not uncommon, I maintain that it is less frequently observed than the rhonchi in phthisis; and in my experience I have heard it when no other signs of the disease were present;

when the balance of testimony was in favour of there being present only a moderate amount of bronchial congestion, and an abnormally thickened or scanty mucus.

The humid click is much the same sign; the difference in sound being due to the presence of a thinner and more copious secretion.

In the first stage of phthisis, other auscultatory lung sounds besides those already noted are occasionally heard, but in comparison with these are extremely rare, and their absence amounts to nearly nothing as evidence of the absence of phthisis.

Their presence has occasionally served to warn me that the lung was not healthy, and I have observed that the sounds referred to have in several cases been followed by the ordinary well-marked signs of pulmonary consumption, and have really depended upon the presence of tubercle.

The first sound to which I shall refer is a humming sound. This I have distinctly heard in some fifty examples of suspected phthisis. I have heard it most frequently under one clavicle. The next most frequent site of it is the lateral region, and after this the supra-scapular region. The humming has been pretty uniform during the whole respiratory period. I have found it loudest in some examples during the expiration. It has been noticed by me to occur more frequently in cases marked by recent hæmoptysis than otherwise. The subjects of this sign have not been wasted for the most part. I have heard it occasionally at the base of the lung, when the upper lobe or apex has certainly been consolidated by tubercle as denoted by coarse respiration, long expiration, and local dullness on percussion. The mechanism of this sound has perplexed me. I have occasionally been inclined to regard it as a sound due to the blood, and the finer veins thrown into a state of undue vibration, by the partial presence of tubercular deposit in a minor degree. The continuity of the sound has greatly contributed to this view, and the occurrence of this sign in hæmoptysis cases, in which the blood may reasonably be believed to be thin, and more prone to be thrown into eddies, seems to favour this opinion. Yet I admit the difficulty which presents itself, on account of the thickness of the walls through which such sounds so originating would have to travel. That the sound in question has not proceeded from movements in my own ear I have satisfied myself, for when others have listened the same acoustic results have been obtained. To discover this humming sound, a good deal of attention is requisite, but I believe that this, and a moderately acute ear, will secure its detection. Such a sensation will be obtained by means of attentive audition, as to lead to no doubt of this sound being present. A buzzing sound has been occasionally heard by me, in examples of probable phthisis, in which cough, obstinate in character, and wasting, have been present, and in which no percussion dullness or other physical sign was present. I have made this sound out in a good many examples under the clavicle and at the base of the lung. I have occasionally heard it at the base of the lung when there has been abundant evidence of the presence of tubercle to some extent at the apex. Some few examples of this sign, at first isolated and alone, have been followed to my certain knowledge by the usual confirmed signs and symptoms of pulmonary consumption. In not a few of the cases in which this sound has been heard, hæmoptysis had been recently present, and to some considerable extent. This sound has shown the same continuity as the last described one. The mechanism has offered the same difficulties as the last sound, but I have been disposed to believe it much the same as that of the humming sound.

A sound resembling that of arrowroot powder pressed by the finger, I have occasionally heard in persons in whom there were present symptoms of phthisis, such as cough, shortness of breath, and wasting. I have been able to ascertain the fact that the ordinary physical signs of phthisis have subsequently occurred in a few examples of this sound. I have certainly heard it at the base of the lung when there have been unmistakable signs of tubercle at the apex. It has been occasionally associated with dullness on percussion, deficient respiration, and defective expansion. It has also been occasionally heard under the clavicle. This is a form of dry crepitation: it is very fine, and requires some attention to discover it. It is during expiration that this sound is chiefly heard. When it is heard both during inspiration and expiration it is loudest and longest, for the most part during the latter act. The mechanism is different from that of the above described sounds. It is evidently the result of an impeded contraction of the fibrous tissue of the air cells. The air in the vesicles is somewhat impeded in the exit by pressure, and the expelling force of the elastic fibre acts in consequence in a very slightly jerky manner. The dry condition of the air cells seems to promote the generation of the sound. The sound is too fine to depend upon pleural friction.

WOOL OR YARN TEARING SOUND. — Another of these fine sounds which I have occasionally heard at a period very early in the first stage of phthisis, and when the disease could not be satisfactorily proved to exist by the ordinary physical signs noted in previous pages of this work, is a rather coarse distension sound, occurring at the latter part or even the termination of a forced inspiration. The sound is such as might be produced by the distension of air-cells more than usually difficult of expansion and unduly resisting. It has resembled the sound produced by drawing out wool or yarn in a gentle manner, or by gently, yet with some force, blowing into it. This sound is heard chiefly under the clavicle and above the third rib. It has been generally associated with cough, deterioration of the health, and has occurred on the approach of the more certain kinds of phthisical signs. Slight fine very localised sibilus has occasionally been allied with it. I have sometimes heard it when the conclusive signs of phthisis have been present. I regard this sound as more suspicious than the others just described, yet I think it may with propriety be placed in the same category with them, viz. suspicious signs, or signs of probable phthisis.

Rolling or hollow shell sound is another sound which I have occasionally heard developed in the first stage of phthisis. It resembles the wool or yarn tearing sound and the buzzing sound, but it is different, and would not be accepted by a non-professional hearer as such. It is a noisy but not highly pitched sound: it seems to come from a number of little spots such as the pulmonary vesicles or terminal tubules. It seems to arise from the stretching and inflating of fine tissue reluctant to move in inspiration, and from slow contraction upon air so confined by dense tissue as to be with difficulty expelled. This sound has a resounding tone as if it were originated in tissue, surrounded by structure well supplied with air. The sound is as if the movements causing it took place in a shell, and it has sometimes a character of fine rolling, as of a carriage. It is pretty uniform throughout inspiration and expiration. It continues some little time after the conclusion of expiration, as denoted by the fall of the ribs, and is sometimes maintained throughout the whole interspiratory period, but becoming a little less loud. A forcible inspiration increases its loudness and fullness, but it is very easily detected in calm breathing. I have no doubt whatever, that this sound is a valuable sign of phthisis at a very early period, but I would not say that it is not often present in simple congestion, and in other minor affections. Yet I have much more frequently found it associated with phthisis and with some of the ordinary early signs of this disease than otherwise. It has happened that I have had two specimens of this sound lately under my observation. A young man, valet to a nobleman, presented it. He was wasted, hectic, coughing, and had some dullness on percussion, and an occasional moist crackle at both bases and right axillary region. The respiration sound was rolling, shell-like, rising a little at the end of inspiration; it was also deficient. This character of sound was heard at both apices and in the axillary regions.

I heard the same sounds in a young man, a baker, named Stephens. He was pallid, short of breath, troubled with cough, and was wasting. He had dull percussion, and an occasional moist crackle under the right clavicle. The sound, rolling in character, was heard on both sides at the apices, but most on the right. With the differential stethoscope great deficiency of respiration was made out at the right apex. This sound increases in the second stage of the disease, till it becomes masked by the loudness of humid crepitation. The mechanism of its production seems to be that which the hearing of it suggests, and which, in a previous paragraph has been already described.

The above fine sounds are by no means unequivocal signs of phthisis, for they are heard when it is impossible for us to conclude for certain that tubercle is present; yet, as they have been known to be followed by unequivocal signs of phthisis within a short period, and are often associated with phthisis, they may be regarded as of value, and warranting a suspicion either of the presence or of the approach of pulmonary consumption. They are certainly not healthy sounds. It would be unwise, in the highest degree, to disregard the warning which these sounds afford of the probable presence or approach of tubercular disease, knowing, as we do, that phthisis, when present to that extent which is usually attended by dull percussion, dry crackle, or bronchial respiration, is very difficult of cure or of arrest. It seems most desirable that every sign which can be obtained that will lead to an early diagnosis of phthisis, or even to a reasonable suspicion of it, or, as it may be called under the circumstances, probable phthisis, should be made available, and assist us in the decision of a difficult and most important question.

PLEURAL FRICTION SOUND.— In the first stage of chronic phthisis, the pleural friction sound is rare, more rare than in the second. This sign consists of a coarse interrupted sound, as of a rough body moving upon a soft one, or of two rather roughened bodies moving on each other. From the sound of silk cloth rustling upon silk cloth, it may reach to the sound of a rough finger moving upon the skin, as listened to by the stethoscope. In my experience it has never gone beyond the latter character in roughness in the first stage, unless there was present old pleuritic exudation. In the third stage of phthisis the friction sound attains occasionally to the coarseness of scraping or grating, such as might be produced by moving a roughened bone over the skin, but of this mention will be made at the proper time. Friction sound, in my experience, is seldom heard under the clavicles, and when present is usually discovered at the inferior dorsal and lateral regions. I believe it is often confounded with really lung sounds, for many so-called friction sounds have been associated with moist crackle. It is of little use as a sign of incipient phthisis, but when present it is never to be disregarded, for it is usually associated with pleurisy or impending pleurisy. Of pleura sounds more will be said in the discussion of the later stages of pulmonary tuberculosis. Effusion of liquid into the pleural cavity occasionally takes, giving rise to abolition of respiration sounds and to the production of ægophony; but these signs will be discussed more properly at a later period.

The crepitation of pneumonia is occasionally heard in the first stage of phthisis, but much more rarely than in the second and third stages. In some few cases of chronic phthisis it is early manifested, but it is in the acute form of phthisis that its early manifestation is chiefly observed. It is not uncommon for the fine crepitation of pneumonia to inaugurate the deposition of the diffused tubercle and the tubercular points of acute phthisis.

The crepitation of pneumonia is the noise produced by the explosion of very minute air vesicles in or near the vesicles of the lung. They vary from the size of a pin point to that of a millet seed. The explosions are very numerous at the same time. They occur with the inspiration and the expiration, but most with the inspiration. Their duration seldom exceeds that of a few days. This sign is heard chiefly in the inferior dorsal and lateral regions. Being much more a sign of phthisis, or of a complication of phthisis in the second stage, its full consideration will be found in the description of that stage.

A larger and louder crepitation is not unfrequently heard in the first stage of phthisis, though less frequently than in the second and third stages. It is the sub-crepitant rhonchus of authors. I propose to call it medium crepitation. It is usually dependent upon the presence of capillary bronchitis; I have known it to proceed from the presence of blood and sanguineous liquid in hæmoptysis, and of serous liquid in persons affected with anasarca. This sound has a larger range than fine crepitation, being often heard over a large proportion of one lung. The explosion of air vesicles is its cause. These air vesicles are considerably larger than the vesicles of pneumonia, and I believe have the size of small shot or mustard seeds. This sound is generally accompanied with sibilus and some sonorous rhonchus. It is of more lengthened duration than fine crepitation. When occurring with hæmoptysis it is usually of very short duration. When associated with an anasarcous condition, it is usually of long duration, and is disposed to become more diffused. But of this sign more will be said under the second stage.

CHAP. IX.

FIRST STAGE: AUSCULTATION—*continued.*

Thoracic Voice, sometimes increased sometimes reduced.—Nature of the normal thoracic Voice.—The thoracic Voice unaffected by very moderate Deposition.—Exalted Voice.—Bronchophony.—Loud forcible Voice.—Seat of increased Voice.—Voice naturally loud.—Increased Voice dependent upon other Diseases.—Cavity Voice mistaken for the loud forcible Voice of Phthisis.—Varieties of thoracic Voice in Phthisis.—Differential Stethescope.—Mechanism of Voice.—Acoustic Experiments on Lungs.—The Bronchophony of Phthisis and other Diseases.

THE thoracic voice in phthisis is an important element in diagnosis, and I shall therefore treat not only of this sign in reference to this particular disease, but make some general observations on it.

The voice heard through the thoracic walls is found to be altered in the first stage of phthisis, and this alteration is one of the earliest signs of the presence of tubercle of the lung. The vesicular murmur is seldom materially roughened or divided without the thoracic voice becoming affected, and this alteration becomes more manifest as the first stage advances, as the deposit of dry tubercle proceeds, as bronchial and defective vesicular respiration are established. Up to this moment the thoracic voice is augmented and unduly distinct. But when the deposition and the consequent consolidation have proceeded so far as to nearly prevent the passage of air through the bronchi, greatly to narrow their calibre, to render them comparatively motionless under the influence of the vibrations of the larynx and trachea, with their consonating column of air, the thoracic voice is reduced, and becomes feeble and indistinct.

I am in doubt whether in general the voice or the percussion note is first altered; but I am inclined to think that after the vesicular respiration is decidedly affected, the modification of the thoracic voice in the first stage of phthisis, is the next sign upon which we may depend. The alteration in the percussion note, I am disposed to believe, comes immediately after. Possibly in many cases the percussion note may be modified simultaneously, and in some cases may be even found to be the first sensibly modified.

The voice heard through the thoracic walls, either immediately by the application of the ear, or mediately by acoustic instruments, either flexible or non-flexible, is the laryngeal and buccal voice carried to the outer walls of the chest through various media. Whenever heard, the voice must have descended from the mouth and larynx, partly through the solid walls of these parts, of the trachea, and the bronchi, but chiefly through the enclosed column of air, to the lungs. The voice is carried to the chest by means of an instrument, truly a wind instrument, to the efficiency of which it is necessary there shall be, 1st, a continuity of solid materials; and, 2ndly, an enclosed uninterrupted column of air. If these conditions be absent or impaired, the voice will not duly reach the chest. And if the walls of this living wind instrument be materially altered, either by rigid thickening, or by partial occlusion by means of mucus, &c.; or if the column of air be feebly acted upon by the muscular movements of the chest and larynx, or by weak or impeded vibrations of its containing walls, the voice will be but feebly conveyed to the parts beneath. If the column of air be great and powerfully acted upon, the voice conducted down will be ample. Causes hindering the vibration of the walls of the tube, fixing it, and narrowing its calibre, — such as tumours pressing upon it,—will reduce the voice transmitted, and part of the result observed will be due to the column or columns of air in the lungs consonating to a small extent only.

Without the enclosing walls, the air would be all but powerless to carry the voice, and without the contained air the containing walls would scarcely at all, or very imperfectly, conduct the voice to the chest and its contents. Free unconfined air is a very imperfect conductor of sound, compared with an enclosed column of air, and a solid cylinder, particularly if flexible, is an imperfect conductor of sonorous undulations compared with a hollow one. This latter fact is readily ascertained by experimenting with cylinders of glass, iron, wood, or gutta-percha. The air column then greatly aids the solid larynx and trachea in transmitting the voice; and again, the confining walls of the trachea and larynx greatly aid in the same office. It is to be understood, however, that the column of air is the chief medium of the natural thoracic voice.

At the upper part of the sternum, and at the interscapular region, the large divisions of the trachea, are brought almost directly in contact with the walls of the chest, no pulmonary yielding pad intervening, and the voice conveyed at once slightly through the bronchi, and chiefly through a large column of air, to the walls of the chest, is transmitted through them, and is heard per the ear placed upon the outer surface, with little alteration. The voice at these parts is weaker in some measure and is slightly dulled by the intervening solid material, but has its distinctness preserved almost intact.

At the other parts of the chest the thoracic voice is different. Conveyed at once to the lung, which lies immediately between the bronchial tubes and their contained columns of air and the solid walls of the chest, the voice is there interrupted and muffled, and reaches the outer surface in a comparatively indistinct and humming tone, and as if proceeding from a little distance.

This distant, indistinct, and humming voice is worthy of careful study. It should be well impressed upon the auscultator's mind, so that deviations from its characters may be at once recognised as such. Without a knowledge of the standard, how shall we recognise deviations from it!

In health, in almost all persons, the voice somewhat muffled and indistinct, without much sensible vibration to the ear or hand, and free from wooden-like or metallic-like tone, is heard over the chest with the exception of the sternal region, the interscapular region, and on either side of the spine down to the 12th dorsal vertebra, where it is more distinct.

This humming voice is more voluminous and loud under the right clavicle than under the left. The difference being obvious, and often very striking. The explanation of this fact is probably to be found in the larger calibre of the right bronchus.

The voice is better heard at the exterior of the chest the louder the individual speaks. The grave voice is better conveyed to the ear placed upon the chest, than the treble voice, and it is accompanied with more thoracic fremitus.

In some children in perfect health the voice is heard under the clavicles with remarkable loudness and distinctness, nearly as much so as through the atmosphere. It is occasionally accompanied with sharp, clear, almost metallic tone, as if the ear were receiving the sound direct from a metallic tube of the calibre of half an inch. The mobility, elasticity, and thinness of the thoracic walls in children may explain this fact. These parts may, and doubtless do, accept sound from air bodies, such as vesicular lung, with less difficulty than heavier and thicker materials, such as the walls of the thorax in the more advanced periods of life. In many old persons, when the laryngeal voice is strong and grave, the thoracic voice is very strong. The comparative rigidity and thickness of the bronchial tubes seem to aid in this result.

But to proceed to the voice in phthisis, we find it is universally stated that it is increased in the first stage, though to this sign various degrees of value have been assigned. Good observers have regarded it as of little value by itself, but as I have to deal more with those facts which I have myself observed than with the opinions and statements of other writers, I proceed to record my own convictions.

When only a few tubercles are scattered through the apex of a lung, I believe that no sensible alteration of the voice takes place, even though rough respiration sounds and sibilant rhonchus are present. Of this I have satisfied myself by long *clinical observation*, and by many *post-mortem examinations*.

When the tubercular deposit assumes the proportion of about one-fourth of the entire bulk of the apex, giving to it an obvious increase of weight, imparts a degree of firmness and resistance such as that of the white part of a loaf of bread two days after it is baked; when the secondary and tertiary bronchi, those varying from the size of a goose to a crow quill, are invaded or compressed to a considerable extent, so as to reduce the quantity of air passing to and fro, and while the main bronchi are uncompressed so as to retain freedom sufficient for full vibration, and the lining membrane is not thickened, and the tubes themselves are free from liquid, the voice will generally be found to be increased in intensity and resonance and *seeming proximity*. This form of thoracic voice resembles the bronchial voice between the scapulæ. It has been compared to the tracheal voice, but I think unhappily, for this latter has a cavity character. This is the bronchophony of authors.

When the lung has become as firm as the usual plum pudding from the presence of tubercle and of fibrin, the result of inflammatory action, and from the expulsion of air from the vesicles and bronchial tubes, and when the main bronchus is still unimpaired in its capacity to contain air and to vibrate, the voice will be strong, ringing, and indistinctly articulating, but it will not partake of the character of superficial cavernous pectoriloquy which we find in cases marked by the presence of superficial large cavities, with thin membranous walls, in the third stage of the disease. The voice is more vibratory, and sounds as if it comes through solid material. This form of phthisical voice is very common. It may be called the loud and forcible and solid voice of phthisis. The sound certainly indicates solidity. It often possesses a metallic quality, and shakes the stethoscope; unlike the whispering, articulating pectoriloquy of caverns, it is lost during whispering.

The strong vocal resonance is worthy of most suspicion as the associate of phthisis when it is confined to one part — to one apex. When increased vocal resonance of the right side marks the presence of tubercle there, the excess over the left side is not of moderate extent, only such as is usual in health, but is very great. To be of any value as a sign on the right side, the voice should be very great. When the increase of vocal resonance is observed on the left side, and it exceeds that of the right side, we may be tolerably sure that dilatation of the main bronchus has taken place as in sacculating bronchitis, or that solidification of some kind has become established; and if there be much mucous expectoration, clicking, and dull percussion sound, it is extremely probable that extensive tuberculisation is present.

The subclavicular regions are the earliest seats of increased thoracic voice. It is almost invariably manifested on one side only at first. At a later period it is heard at the scapular regions and towards the base.

When strong vocal resonance has succeeded to naturally weak vocal resonance, the suspicion of tubercle is increased.

It generally happens that the increased vocal resonance of phthisis, even in its first stage, is associated with other abnormal conditions, in respect of A, the general strength, B, emaciation, and C, other physical signs; so that in attaching value to it, we are seldom left to deal with it as an isolated fact.

The intensity of vocal resonance is often associated with conditions altogether unconnected with phthisis. The strength and gravity of the natural voice may give rise to it. Persons with large and capacious larynx and trachea generally afford great vocal resonance. Thin movable walls of the thorax aid the emission of the voice, as already remarked. The presence of hepatisation of the base of the lung I have observed to give rise to increased vocal resonance under the clavicle. I have known empyema attained to a considerable extent, to be associated with decided increase of vocal resonance when it has been impossible to refer it to any other condition except the effusion within the pleural cavity.

When great vocal resonance is discovered in the front part of the chest, in the first stage of phthisis, it is also discovered, for the most part, at the posterior corresponding surface.

On the whole, I am disposed to attach little value to the thoracic voice as a means of determining the presence of tubercle in the early period of the first stage of phthisis. But it is in every way desirable *to know its conduct in this disease.*

The voice is often increased beyond what is the average loudness, not only when no tubercle is present, but it frequently happens, that even in phthisis no increase is found until a late period of the first stage. I believe that the increased loudness which has been often taken for that of the first stage of the disease, has been in reality the increased loudness of the third stage, when cavities filled with air, and having a communication with a large bronchus, have been present, but which, from the absence of secretion, have afforded no large liquid crepitation or gurgling sounds. The pectoriloquy of dry silent cavities, associated with only very little dullness on percussion, and little deterioration of health,—a contingency by no means rare,—I believe has often been accepted by even good auscultators for increased vocal resonance appertaining to the first stages of the disease. Of this I feel convinced, for at the hospital I constantly meet with cases in which cavities are present, of which increased vocal resonance, is for a time the chief sign.

The frequency of the presence of exalted vocal resonance, then, in the first stage of phthisis, I hold to be very considerably less than is maintained by other physicians, and I do so on these grounds: 1, that I have failed to detect it in very many cases of the disease, except in the latter periods of the first stage; and, 2, that many of the cases in which it has been observed by others have appeared to me in reality to be cases of phthisis in its third, and only nominally in the first stage.

It has been only when tubercle has been deposited to such an extent as to impart considerable weight and solidity to the lung that it has augmented vocal resonance.

From the preceding observations, it follows that the thoracic voice, in the first stage of phthisis, is found in different forms. 1st, We have the natural voice; 2nd, The bronchophonic voice, with its loud tubular characters; 3rd, The solid, loud, vibrating, forcible, and often metallic toned voice of solid lung in full undulation; 4th, The reduced voice dependent upon weak laryngeal voice, either natural or resulting from phthisical implication of the larynx; and, finally, 5th, The weak voice dependent upon great solidification of the lung, and compression or obliteration of the bronchial tubes cutting off the necessary supply of air in sonorous undulation.

The natural voice remains when tubercle is thinly scattered over the pulmonary structure.

The bronchophonic voice occurs when there is sufficient tubercle to impart some degree of additional weight and firmness to the lung, when thus preventing the ordinary dispersion of the sound throughout the lung, the resonance of the voice in the tubes is increased, and when this increase throws the bronchial walls and surrounding pulmonary structure into moderately increased vibration. This occurs earlier than the latter form of abnormal voice.

The loud, forcible, solid voice takes place when the lung has become dense, heavy, and greatly loaded with dry tubercle, or firm with fibrinous deposit now contracted; when the laryngeal voice is strong; when the resonance in the bronchi is very great, and is equal to the task of throwing firm and heavy lung into vibration. This is the successor of the last described abnormal form of voice, and it frequently gives place to the fifth form—the reduced voice of compressed bronchi. It is generally confined to one side; its most common seat is the sub-clavicular, but it is commonly heard in the axillary and infra-scapular regions. It is accompanied with fremitus for the most part, and commonly suffices to cause the stethoscope sensibly to vibrate, and even to shake the head of the auscultator. It is common at a later period of the first stage, and in those cases of phthisis that refuse to proceed to the second stage. It is not heard at a very early period. I believe this is the form of thoracic voice that has brought some discredit upon auscultation, in so far as it has been taken for cavernous voice. It is well known, that formerly auscultators frequently inferred the presence of cavities from a certain character of the voice,

—from what is called, perhaps somewhat vaguely, pectoriloquy, when, as revealed afterwards by post mortem examinations, none were, or could have been, present. It was doubtless this form of thoracic voice that, mistaken for cavernous voice, gave rise to this error. The absence of gurgling and of cavernous cracking or bubbling, and the loss of the sign on whispering, will serve to distinguish the loud forcible voice of the first stage of phthisis from the cavernous pectoriloquy of the third or cavity stage of the disease. This is a form of bronchophony like the last described variety of voice. It is usual to find this sign either confined to one side, or more developed on one side than on the other.

Reduced thoracic voice is not uncommon in the first stage of phthisis. It occurs when the voice is naturally weak, or when from debility it becomes so. Reduction of the voice occurs by no means unfrequently when in consequence of laryngeal inflammation and ulceration the voice loses its force. When, from these causes operating, the thoracic voice loses its strength, reduction is observed to hold throughout the chest. In some examples I have found the reduction to hold less in respect of the immediate seat of the disease; but in other examples again the reduction has been most marked there. Reduced voice occasionally occurs in the first stage of phthisis from an excessive amount of consolidation, or from the consolidation being, so to speak, in excess of the supply of air through bronchial passages. I have occasionally found this at the apex, but I have met with it much more frequently at the base of the lung, and posteriorly. The vocal undulations, descending into the condensed lung and compressed bronchi, are not sufficient in volume and force to cause free consonance or resonance of the tubes and solid parts. It is in the latter periods of the first stage that we most frequently find this sign. It is common in cases which have been marked by pneumonia. Full percussion sound always attends it.

For the detection of differences in the intensity and character of vocal resonance at two parts of the chest, of two corresponding parts of the right and left side, the differential stethoscope proves of great value. The method of using it is this:—Place the two cups on the two different parts at the same moment; if the voice be materially greater at one part than another, the ear connected with that part seems the only one through which the observer hears. If the difference be not material, then it is best to apply the cups in succession. As soon as an observation has been made with one ear at one part, another observation may be taken with the other ear at the other part. A very minute difference may be thus clearly appreciated. The difference, now strongly revealed to the mind, both in intensity and in character, may be entirely overlooked by an auscultator employing the common wooden stethoscope.

The mechanism of the alterations of the thoracic voice in the first stage of phthisis deserves attention, and I shall treat of it in a comprehensive manner.

It has been universally considered by auscultators that a very sufficient and satisfactory solution of the phenomenon of increased voice is obtained by an increase of the sound-conducting power of the lung as it loses its vesicular character and takes on more and more of the condition of solidity. The tuberculating lung approaches to the condition of a solid contradistinguished from a body enclosing a large quantity of air; and as it is an acknowledged fact, that solids convey sound better than liquids or gaseous bodies, it has seemed natural and justifiable to find, in this increased density, a sufficient explanation of the acoustic fact observed.

Laennec was of opinion that solidified lung conducted sound better than healthy lung; and his view received universal assent until the contrary was advanced some years back by Skoda, the celebrated German auscultator. Skoda maintained that the sound-conducting property was reduced instead of being increased; and, therefore, he concluded that no alteration in regard to the conduction of sound could be held to solve the occurrence of increased vocal resonance. It is to Dr. Markham and Dr. Herbert Davies that the profession in this country are indebted for the diffusion of the knowledge of Skoda's views. Dr. Herbert Davies, in his work on the "Physical Diagnosis of the Diseases of the Lungs and Heart," gave a good account of Skoda's views; and more recently Dr. Markham has favoured the profession with a translation of this German physician's work. Dr. Herbert Davies adopts the greater part of Skoda's views on the thoracic voice, but declines to admit that solidified lung conveys sound worse than vesicular lung.

Skoda refers the increased thoracic voice of phthisis, in its first stage, to the acoustic principle of consonance. He believes that the increase of sound is due to reflection of sound from abnormally dense bronchial walls, and to the air in the bronchi taking on in excess the same sonorous undulations as those of the air contained in the larynx, and that the amount or sum of sound is thus increased. Consonance takes place more fully in tubes rendered rigid and surrounded by an amount of substance unfavourable to the transmission and diffusion of the original sound. Now this is what is found in phthisis, for the tubes are surrounded by condensed tissue unfavourable to the exit and diffusion of sound. The sound undulations are therefore confined.

The consonance of the contained air will be greatly promoted by these conditions: a thickened state of the lining membrane, a rigid condition of the cartilages, and a surrounding tissue deprived of air. These conditions will serve to retain and to reflect sound. It is right to observe, however, that these conditions may be carried too far, and, in reference to the *sound* may be excessive *and destructive of it.*

To proceed to describe what I myself believe to be the true solution of the increased vocal resonance of phthisis in its first stage, a task, by the way, which I find greatly more easy than detailing the views of other observers.

This is what I believe actually happens when in the first stage of phthisis increased thoracic voice is observed. The voice descending from the larynx into the bronchial tubes is prevented reaching to the vesicles and terminal bronchi, and even the penultimate bronchi, by the presence of tubercular matter now filling them, and by the pressure of the adjacent adventitious materials, such as fibrin, and by the presence of a great amount of blood in the surrounding tissue, and also by the mucus and serous fluid occluding the passages. The sonorous undulations of the air are abruptly stopped in their exit from the bronchi, and in their process of intimate division and of rapid decay. They are reflected, and the cavity being small, the undulations of sound are multiplied, the walls of the still pervious bronchi are thrown into unwonted vibrations, and in fact they consonate. The result of all this is, that such an increase of the ordinary sound is procured in the bronchi, that the voice is carried to the walls of the chest in a materially intensified amount.

That increased sound in pipes or vessels is procured through consonance or resonance, by dealing with them so as to retain the sonorous undulations of this contained air, may be satisfactorily proved and illustrated by the following experiments.

A. Sound a bell by drawing a violin bow gently and slowly across its edge so as to obtain its lower or graver notes; place a cylinder of wood or pasteboard, open at both ends, about a foot in diameter and a foot and a half long, before the sounding bell so that it shall receive the sonorous undulations of the bell; now suddenly close the further end of the cylinder. The moment the cylinder is closed a very great increase of sound is procured, for the box consonates under the influence of the sonorous undulations arrested in their exit from the cylinder. A box already closed at its further extremity suddenly made to approach the bell answers well.

B. Sound a boy's common tin pipe or flute, now much in use as a child's plaything; sound again with most of the openings closed. The second sound is much louder, and the vibrations of the pipe are increased sensibly to the touch.

C. Take a glass shade, hold it in the air and apply to its closed end a musical box; now close the open end of the shade by placing it lightly on a table, or by any other means: the sound has now become intensified, and the vibrations of the glass are made more manifest to the hands. The increase of the sound is further ascertained by placing the ear in immediate contact with the glass shade.

D. The increase of sound in a cavity may be again exhibited by preventing the diffusion of the sonorous undulations of the air in this manner:—Take a bag of india-rubber or a bladder, some four inches long and some two inches broad; fit into one end a piece of india-rubber tube a quarter of an inch in diameter and a foot long; adapt to the free extremity of the tube a mouth piece of wood, such as the object piece of a stethoscope; speak into the tube, and, by means of a flexible stethoscope placed upon the bag, listen to the sounds conveyed to it. Now contract the dimensions of the bag by pressing with the fingers, or by folding up the side or further extremity, and the voice sounds will be found to be materially augmented. The resonance is increased in proportion as the diffusion of the sound up to a certain point is prevented, the entrance remaining the same.

But the presence of increased resonance of the bronchi, air, and lung in the first stage of phthisis, as described, is not the only cause of the increased voice at the surface of the thorax. Another acoustic principle comes into play, and materially aids the result. This, I believe, has not previously been noticed in thoracic acoustics. It has been ascertained by experiment, that sounds are better communicated to solid bodies, such as the walls of the chest, by solid than by aeriform bodies. Now, a tuberculated lung is a solid body compared with vesicular lung, which may be regarded as an almost aeriform body, and it might at once be inferred that the first would be more likely to convey sounds, or to impart them to a solid body, than vesicular healthy lung would do.

I have found by actual experiment that vesicular lung, in a state of sonorous undulation, transmits sound worse to a solid wooden stethoscope than to a flexible air stethoscope, while on the contrary a piece of hard boiled beef transmits sound much better to a solid wooden stethoscope than to a flexible air one. I have also found that liver and vesicular lung have the same sounds conducted differently through the breast of a sheep and a wooden stethoscope. The liver experiment results in most sound.

Thus it would appear that the acoustic advantage of increased resonance in the case of lung solidified by means of tubercle, is aided in producing increased thoracic voice by the principle that one solid body transmits sound better to another than an aeriform body transmits it to a solid body. Numberless experiments have satisfied me that the momentum or force of a body in sonorous undulation must bear a certain ratio to the weight or resistance or inertia of the body to which it is to transmit its undulations; i.e. that a solid body requires a greater force than a liquid one, and a liquid one a greater force than an aeriform one. In this way the greater power over the walls of the chest exercised by solid lung, compared with vesicular lung, contributes to the observed increase of thoracic voice.

For analogous phenomena, let us make a few experiments. 1. Place the end of a wooden rod successively upon two bags, one filled with air and another filled with water, and we shall find that more sound is conveyed when the rod is placed upon water than when placed upon air. 2. Place two rods, one of wood and another of iron, in water in a state of sonorous undulation, and we shall perceive that more sound is conveyed through the wooden rod than through the iron one. In the first experiment the water has more momentum than the air, and in the second the iron having a weight and resistance too great in proportion to the momentum of the water, the sound is only imperfectly taken up by it and transmitted to the ear. Further, if in the case of the water we experiment with wood and with a lighter conductor, viz. air in an india-rubber tube, we have a still more remarkable result, for the air in the tube having less resistance than the wood, and the momentum of the water being only moderate, the sound is much better communicated than by the wood. But be this explanation true or erroneous, the acoustic fact remains unaltered.

It has been said at a previous part of this article, that great thoracic resonance is occasionally present when there is no consolidation of the lung, and this happens when the voice is grave and forcible, and when the bronchial passages are unusually large, either from natural conformation, or from dilatation from disease. On the other hand, it frequently happens that that amount of consolidation from tubercle is present in phthisis in its first stage, which might be supposed would be calculated to increase tubular resonance without this phenomenon being observed. In fact, I have not unfrequently found in the first stage that the thoracic voice was reduced. This absence of increased thoracic voice, and this reduction below the natural standard, when, from surrounding sound, obstructing tubercle, and other material, the contrary might be expected, are found to depend on various conditions. One, and a not infrequent one, is a certain weakness of voice depending upon incipient disease of the larynx. The voice is low, occasionally rather high in pitch, cracked and irregular, occasionally husky or hoarse, sometimes falling as low as a whisper. This, though not so frequent in the first stage of phthisis as in the second, and still less so than in the third stage, is by no means unusual. It depends upon a dry, swollen, partially occluded state of the larynx and the rima glottidis, and a somewhat rigid condition of the vocal chords. This again depends upon chronic inflammation spreading up from the seat of the tubercle, and occasionally resulting from the passage through this canal of acrid secretions from the diseased part. The vocal sounds are ill formed.

The volume of air originally thrown into vibration is small, and consequently the undulations transmitted to the bronchi are feeble, and incapable, even with all the reflection and closing in of which they are the subject, of that amount of resonance sufficient to throw the bronchial walls and the solid lung into sonorous motion sufficient to produce augmented thoracic voice.

Another cause which occasionally prevents that amount of resonance sufficient to produce augmented thoracic voice, is the presence of a great amount of tubercle, compressing the bronchi, and completely nullifying in this way the resonance of the air in the tubes. The tubes are so compressed that they refuse to vibrate in unison with the contained air. This occurs in those cases in which the lung becomes very dense, heavy, and occasionally augmented in size. Though this is a frequent cause of non-augmentation of thoracic voice, and even of unduly weak thoracic voice, it is less frequently thus in operation than fibrinous and cancerous deposits. These latter materials prove more obstructive of the larger air passages than mere ordinary tubercle.

Another condition which counteracts the tendency of simple tubercular deposit of moderate extent to produce increased thoracic voice, is the presence of liquid, such as thin mucus, blood, or purulent secretion in the bronchi. This serves very effectually to reduce thoracic voice. Unless the undulations of the air break down the partitions of liquid, the voice is interrupted. Would we ascertain by experiment how much sound transmitted by air through an air tube, is impeded by the presence of even a very little liquid, let us place even so small a quantity as one drop of water in an indiarubber hearing tube, or a flexible stethoscope, so that at some one very little spot the entire calibre of the tube may be occupied by it, and we shall find that sounds previously heard in force, are now heard very feebly and indistinctly. We can thus understand how it is that, in phthisis, the thoracic voice may now be augmented and now reduced. The liquid comes and goes.

Before concluding my observations on the mechanism of the alterations in the thoracic voice of the first stage of phthisis, I am desirous of adding the results of my experiments upon the comparative sound-conducting properties of natural lung, and lung abnormally altered in density.

The amount of sound-conducting power of the lung is of itself not sufficient to explain the greater or lesser degree of thoracic voice. Conduction, although an element in the process, is not the only one. The amount of the sound that is to be operated upon by conduction is to be considered, and we have already found that the condition of the lungs and the bronchial passages is very operative in this respect. The consonance due to increased density of the lung greatly increases the amount of sound that may be conducted.

If we have an absolute increase of sound by means of consonance, we may have an increase of thoracic voice, although the conducting power of the lung remains the same. The absolute increase of sound is a great element in the increased thoracic voice.

From numerous experiments which I have made, I have satisfied myself of several facts much in accordance with the statements of Skoda.

Sounds communicated from solid bodies, such as a watch, or a table in sonorous undulations from contact with a tuning fork or a musical box, to healthy vesicular lung, are well conducted to the ear directly applied to it; not in an inferior degree than when solid tuberculated lung and cancer lung are employed.

When air stethoscopes, such as my differential stethoscope, are employed, vesicular lung transmits sound from solid bodies much better than when the solid stethoscope is the hearing instrument in use.

When the instrument employed is the solid wooden stethoscope, solidified lung transmits sound rather better than the air stethoscope.

Very dense, tough lung, such as cancer lung, transmits sound even to a wooden stethoscope less perfectly than lung having a little air contained within it. This fact coincides perfectly with what we have stated as to the superiority of hollow wood over solid and hard wood. It also corresponds with the fact which I have ascertained, that dense bodies pierced with holes conduct sound better than when entire; and also with the fact that freedom for motion is promotive of the same result.

Lung in a state of high emphysema conducts sound both to the wooden and the air stethoscope worse than healthy vesicular lung. This corresponds with the principle that gasiform bodies have little momentum, and transmit sound with comparative difficulty to solid bodies.

On the whole, I regard the varying degrees of sound-conducting power in the moderate alterations of the lung, in respect of density, as little operative in the modifications of the thoracic voice which we observe in the first stage of phthisis. I agree with Skoda that it is to consonance, due to the unwonted retention of the sonorous undulations of the laryngeal voice, that most of the result is to be attributed.

The bronchophony of phthisis, in its first stage, must be distinguished from sounds bearing a close resemblance to it, almost identical with it, and which are heard in very different morbid conditions of the lung and bronchial tubes.

A. The bronchophony of phthisis is liable to be mistaken for the same sound in hepatisation. When this sign occurs in conjunction with recent hepatisation, we have the remains of small moist crepitation, and when associated with old hepatisation, the absence of respiration is great compared with the diminution in phthisis in its first stage. In hepatisation the advent of disease is sudden compared with phthisis: the acute symptoms have been sharper and have been of shorter duration, lasting in general only a few days, and have embraced pain, shortness of breath, glutinous transparent, almost colourless, or very slightly rusty-coloured sputum. The seat of bronchophony in hepatisation is commonly different from that of phthisis. While it is found in the sub-clavicular regions in phthisis most commonly, in hepatisation it is almost invariably found at the scapular and infra-scapular regions.

B. The bronchophony of phthisis may be mistaken for the bronchophony of dilated bronchi in chronic bronchitis. But this sign, the associate of chronic bronchitis, is usually accompanied with percussion that is resonant, clear, and of long duration. The sibilus, the snoring and cooing bruits, both with inspiration and expiration, attend bronchitis, and comparatively rarely phthisis. The seat of bronchophony, the associate of bronchitis, is more general than that of phthisis; it is commonly found on both sides of the chest. It is more generally heard at the angle of the scapula than in phthisis. I have generally remarked that the thoracic voice of bronchitis becomes more superficial than that of phthisis in its first stage, both at the anterior and superior parts of the chest, and below the angles of the scapula, and that it is less strong, accompanied by less vibration of the wooden stethoscope.

C. The bronchophony of phthisis is to be distinguished from the pectoriloquy proceeding from a cavity. The pectoriloquy of a cavity usually presents characters in itself which serve to distinguish it from the former sign. The voice is usually clear, distinct, and the letters of each word seem to be distinctly articulated, and so conveyed into the ear of the hearer. When the cavity is large, the voice is, as it were, puffed by a large volume of air into the ear: the air seems to pass into the ear, and without much forcible vibration of the wooden stethoscope, unless the voice be very powerful. Whispered voice is heard with the same characters. If moist, the cavity presents large gurglings. If dry, a crack of a resounding or metallic character is occasionally heard as a bubble bursts in the interior. Blowing bruits, as of air entering or escaping from a chamber by means of a bronchial tube, narrow or rough, are occasionally heard. These blowing sounds chiefly hold during expiration. Then "sawing and creaking" bruits, as if coming from a cavity, are likewise heard. These signs serve to distinguish, with much facility, the thoracic voice of a large cavity from that of phthisis in its first stage. The thoracic voice, proceeding from a small cavity covered by consolidated tubercular lung, is more difficult to distinguish from the thoracic voice of the first stage of phthisis. Yet, with attention, this may usually be done. The voice, if the cavity be small, is usually accompanied with more vibration of the stethoscope than that of large cavities, and therefore more closely resembles the voice of early phthisis. But it is commonly accompanied, if not by gurgling, by large liquid crepitation, which we never have in phthisis in its first stage, unless complicated with a very unusual amount of bronchitis and bronchial secretion. The dullness of percussion, when we have small cavities, not in the first days of their existence, with superincumbent lung, is generally decided, and there is a depression of the chest, and also a deficiency of motion, not commonly found in phthisis with mere crude tubercle.

D. We have the thoracic voice, called bronchophony, in œdema of the lungs; but the seat of this is the infra-scapular and inferior dorsal regions. It is always accompanied with large liquid crepitation, and the percussion note at the anterior and superior thoracic regions is not abnormally dull. The absence of phthisical sputa, and the presence of unusual dyspnœa, without great emaciation, are remarked in œdema.

E. The same thoracic voice is occasionally heard under the clavicle in cases of empyema as occurs in the first stage of phthisis; but no difficulty attends the diagnosis, as the percussion in the former disease is generally clear below the clavicles, and exceedingly dull, or absolutely so, below the scapula. The respiration sounds are exceedingly feeble and distant, if heard at all at the base of the affected side, and the vocal fremitus is entirely absent below in examples of empyema attended with the bronchophonic voice.

F. The bronchophonic sign of phthisis is occasionally simulated in examples of tumour in the thorax. Aneurism of the commencing aorta, when it compresses the bronchi near the bifurcation, is occasionally attended with considerable increase of voice and fremitus: but the pulsation, the murmurs, the disordered impulse, the great dyspnœa, and the dropsy, and the comparatively advanced age of the patient, will generally serve as the grounds for an easy and decisive diagnosis. Mediastinal tumours pressing upon the bronchi give rise in the same way to bronchophony in the sub-clavicular regions. The voice is increased above and reduced below the spot of compression. Dullness of percussion at the sternum, difficulty of breathing, loud blowing tubular respiration sounds, occasional prominence, and the presence of signs of pressure on the great vessels and on the œsophagus and bronchi, serve to distinguish the bronchophony arising from these causes from the laterally diffused bronchophony of the first stage of phthisis.

CHAP. X.

FIRST STAGE—*continued.*

Thoracic vocal Fremitus.—Increased in Phthisis.—Sometimes found on the healthy Side of the Chest.—Sometimes reduced in Phthisis.—Not always associated with increased Voice.—Method of Detection.

FREMITUS.—The fremitus or vibration of the thoracic walls under the influence of the voice, as learnt by the touch and by the wooden stethoscope, is materially altered in phthisis, and in its first stage, though perhaps to a less extent than in the other three stages. For the most part the alteration is one of increase; but it not unfrequently occurs, as my experience has taught me, that the change is one of decrease or diminution.

No sensible alteration of the vocal fremitus is perceived in phthisis, until a very considerable amount of tubercular deposit has taken place. The deposit must be of that extent that will suffice to produce increased vocal resonance, and to give a sensible increase to the weight and resistance of the diseased lung. I should be disposed to say, in the absence of precise actual observations and experiment, that the vocal resonance is usually more early increased to a sensible and reliable extent than the vocal fremitus. I believe a smaller amount of deposit will produce increased vocal resonance than will suffice to cause a sensible increase of vocal fremitus. But as soon as vocal resonance is materially increased, it usually happens that the vocal fremitus begins to augment, and in most examples of disease, though not in all, these two phenomena, viz. increased vocal resonance and increased vocal fremitus, are found to be associated. The increased resonance of the air in the bronchial passages causes the lung to vibrate, and the vibrations of the lung are communicated to the ribs, the intercostal muscles, and the superincumbent soft parts, sufficiently to be perceived by the hand, or to be conveyed to the concha of the ear and the side of the head by means of the solid stethoscope. Absolutely increased and comparatively full vocal fremitus is frequently found upon the healthy side of the chest, when the other side is very considerably advanced in tubercular disease. When by means of great and bronchi-compressing deposit, as well as by extensive expectoration of lung tissue and the free contraction of the walls of cavities, and of the surrounding structure, generally associated with marked depression of the ribs and interspaces, the respiratory acts are almost obliterated, the fremitus of the opposite side becomes exalted, as does also the function of respiration. On the unhealthy side, when the diseased mass is little penetrated by air, the vocal fremitus is reduced, and that on the healthy side becomes so great as to form a striking contrast to the other. The reason appears to be this: the sonorous undulations descending from the larynx being interrupted on the unhealthy side by partial or even great occlusion of the tubes, they are transmitted in preternatural force to the tubes still pervious, and these are situated on the healthy side of the chest.

It is particularly necessary that, in dealing with increased vocal fremitus as a sign of phthisis, we should be sensible of this fact. The comparatively inexperienced auscultator is liable to be led into error, and to conclude that the really sound lung—the seat of increased fremitus,—is the unhealthy one, and that the diseased one, far advanced in the morbid processes, is the sound part.

It has frequently occurred to me to find, in cases of advanced phthisis marked by great consolidation of one lung, increased vocal fremitus on the healthy side, and great deficiency on the unhealthy one.

Increased vocal fremitus is not always associated with increased thoracic voice, and this is easy of explanation: a sound may be so faint and weak as to be inaudible, and yet be attended with motion or vibration perfectly sensible to the touch. Vibratory movements may be considerable in extent, and yet be too slow to emit sound. The vibration of a body must have a certain rapidity of succession to be attended with audible sounds. Mr. Wheatstone has contributed to this subject. He invented an instrument by which the number of its vibrations may be measured. When a number of vibrations, 32 in a second, is produced, no sound is heard, but when they exceed this number, sound is rendered audible, until they exceed 8,200 in a second, when sound is no longer perceived. A very marked illustration of the principle that movements of the air originally attended with sound may be continued longer than sound, is found in the fact that great explosions of gunpowder have produced violent oscillations of the atmosphere at a great distance, sufficient to shake doors and windows, when none of the explosion sound could be heard.

The best method of ascertaining the vocal fremitus is to place the palm of the hands over the part to be examined, and to direct the patient to articulate a few words in a loud tone, and slowly. The absolute characters of the fremitus should be taken at one part first, and then at another. After this is done, the comparative force, &c. is to be judged of by placing both hands at the same moment respectively on the parts that are to be compared. A very good comparison is, however, secured by successive single examinations, either with one or both hands. If both be employed, this is to be done by applying one hand after the other. The hand is to be laid gently upon the chest. The fremitus of the whole chest, i.e. of every part of it, should be taken.

CHAP. XI.

FIRST STAGE—*continued.*

Percussion.—Dullness later than Auscultatory Signs.—Preludes to Dullness.—Deficiency of Air Character.—Reduced Loudness,—Reduced Duration.—Reduced Area of Vibration.—Dullness includes these Alterations.—Adhesions cause Dullness.—Rationale of Dullness.—Amount of Deposit in Relation to Dullness.—Seats of reduced Air Sound.—Dullness in respect of one or both Sides.—The more resonant Side occasionally the diseased Side.—Absolute and comparative Characters.—Dullness in Health; its Causes.—Diagnosis of healthy and unhealthy Dullness.—Dullness of Phthisis masked.—Diagnosis of Dullness of Phthisis and of other Diseases.—Varieties of altered Percussion Sound.—Wooden Dullness.—Absolute Dullness.—Quasi-cracked Pot Sound.

PERCUSSION of the chest is a valuable and easily employed test of the presence of pulmonary consumption. Its revelations are of immense value; but long before these can be procured in a reliable form, auscultation has rendered most important services. In nearly every example of phthisis in its first stage, alterations in the character, in the extent, the force, and the rhythm of the respiratory sounds have been observed, and in many cases adventitious sounds have been heard, sufficient to afford a very strong presumption of the presence of tubercle, before the sound of the chest on percussion has assumed a character decidedly suggestive of tubercle. Auscultation being the first and early deponent, percussion is the second and not tardy witness in phthisis. Auscultation supplies the first tidings; but altered percussion, secondary evidence of the highest value.

In the very commencement of phthisis, when it is most important in many points of view that the presence of tubercle should be indicated to the mind, percussion, as a test, comes later than auscultation, and is therefore of greatly less value. From my own experience I would say that I have never perceived what I shall here designate as phthisical percussion without finding, at the same time, in a more or less manifest form, the auscultatory signs of the same disease; while it has constantly happened to me to find the altered characters of respiration sounds early in the disease, without discovering a percussion note or sign of any kind that could be referred, with anything like confidence, to the presence of tubercle in the lung. The value of the auscultatory signs in the cases referred to was not set down from early examination only, but was confirmed by the subsequent manifestation of the signs of phthisis in its second and third stages.

The alteration of the percussion sound, viz. dullness, which, by the majority of medical practitioners, is the chief or only one regarded or accepted as evidence of the presence of tubercle, is not the first alteration of the sound which I have perceived, and is certainly subsequent in its manifestation to others, it is true, less obvious to the ear, but which possess individual and special characters sufficient to render them applicable to the frequent, and still more so to the habitual, auscultator. However, even these alterations in the percussion sound do not supervene until the auscultatory signs already described have been pretty fully manifested. It is true that the alterations which I shall now notice, graduate into dullness, and at length constitute it; but this result is produced only when they have attained to some considerable extent.

REDUCTION OF AIR SOUND.—The first alteration which is noticeable is that of a moderate reduction of what I shall designate the air element in the percussion sound. When the thoracic ribs, their interspaces, the clavicles, or the supraclavicular space, are struck by the finger, with the intervention of a pleximeter, or of another finger, the tone emitted in the first stage of phthisis has less air sound than natural. The sound is remarkable for this: it is less loud, less continued, less diffused, less vibratory, and it seems to proceed from a body or series of bodies having a smaller extent of area in vibration than is natural.

The loudness is reduced, and we ascertain this by striking in exactly the same manner a corresponding part on the healthy side of the chest, if there be such. The impairment of loudness may become considerable, and keeps pace with the advancement of the first stage of the disease.

The duration of the sound is impaired, and when the deposition of tubercle is considerable it may amount to a quantity that is very remarkable. This reduction of duration may be contrasted by percussing a non-tubercular lung, immediately after this operation upon a tubercular lung. The duration, in rather rough terms, may be set down in this way. The note of a part thickly studded with tubercle beneath is about half the duration of a part free from this deposit.

The vibrations of the chest in phthisis under the operation of percussion seem to be less extensive than those of a healthy part. They give rise to less extensive vibrations of the air. The excursions of the sounding bodies are less when the lung is thickened with tubercle.

The area of the vibrations in lung consolidated with tubercle is reduced. The reduction holds both perpendicularly and superficially; in fact, in all directions. The vibration area is restricted throughout, but perhaps it is more obvious superficially and along the course of the ribs than otherwise, for this reason, that the reduction may be appreciated by the touch. Let a healthy chest and a chest with extensive deposit of crude tubercle be struck (I prefer greatly this vernacular word to the un-English-like word "percuted"), and let the ear carefully compare the results. The portion of the walls in vibration in the healthy chest will seem to be greatly more extensive than in the case of the phthisical chest. This diminution of the vibration area, so to speak, is observable at an early period of the first stage; but it greatly increases with the progress of this period of the malady. Adhesion between the two layers of the pleura are found to be much associated with this reduction of the vibration area.

When these conditions of reduced loudness, reduced continuance, of diminished vibration and limitation of area of vibration have proceeded to some extent and have all manifested themselves, then we have what is usually called dullness on percussion. If one or more, or all of these conditions may exist and be perceived in ordinary practice, before that alteration which is named dullness is established and is recognised, and if these conditions are, as we believe, the antecedents of this well known and well accepted sign of phthisis, it is important to point them out and to call the attention of the practitioner to them. For my own part, I believe them to be signs of phthisis and to be earlier signs than unequivocal dullness. They are therefore in my opinion of very considerable value in diagnosis at an early period, when indeed diagnosis, as far as the patient's welfare is concerned, is of more importance than at any subsequent period. Dullness is the accumulation and the advanced condition of these alterations of sound, or in other words, it embraces them. These alterations are the elements of dullness. They may be observed to occur in various order. The short duration may be the first sign that is appreciated, or it may be that this may not be perceived till a degree of reduction in the loudness has been made out. I constantly perceive a reduced area, a reduced vibration, and continuance in the first stage of phthisis, before I can say there is present what is usually regarded as dullness. I have looked upon the reduced duration of the sound as one of the most reliable signs in the percussion of phthisis.

The conditions which we have just noted have been regarded here hitherto as proceeding from a deficiency of air in the chest; and as being in fact reduced air sounds. But they are yet to be regarded as depending upon another state, viz. that of adhesions of the pleura. But these alterations of percussion sound in phthisis are seldom met alone in this disease, they are conjoined with the same, or nearly the same, alterations dependent upon deficiency of air. When adhesions exist sufficient to impede vibration to an extent that is recognisable by the ear, in general there is a deposit of tubercle sufficient to give rise, to some extent, to the same alterations of sound. The alteration due to tubercle, and the alteration due to adhesions, make up an amount of abnormal sound deviation that is readily appreciable, more so than would be the single alteration due to one of the two morbid states. The amount of sound alteration sooner arises at that height, which we do not hesitate to call dullness, when both morbid anatomical conditions are present, than when only one is in operation. To show that adhesions may suffice to produce the acoustic alterations now treated of, I need only at present remark that these alterations have been frequently noted when post-mortem examinations have proved the non-existence of solidification, or the presence of so small an amount of tubercle or other deposit as could not reasonably be held to account for the acoustic phenomena observed. The alterations in these cases were of course chiefly adhesion and not deficiency of air sounds.

THE RATIONALE OF DULLNESS, OR OF ITS CONSTITUENT ELEMENTS.—When dullness, or its constituent alterations, are present in phthisis, and are due to the presence of tubercle alone, the diminution of the quantity of air in the lung by the displacement effected by the fresh deposit, alters materially the constitution of the chest as an acoustic instrument, so to speak. The lung becomes less of an air organ and more of a solid or flesh body, and it is differently affected by percussion. It varies now in its property of producing sound. An air body, when struck, will emit a fuller, more extended, more lasting, and a louder sound than a fleshy body. Sonorous undulations are more readily propagated through air, particularly if confined, than through flesh; air, particularly if confined, will undulate longer than flesh under a given force. Air admits of surrounding bodies, such as the ribs and the soft intercostal muscles and pleural lining continuing their vibrations longer than flesh does, and permits of a greater extent of vibration. Air offers less mechanical hindrance to the vibration of surrounding solid bodies than a more dense body. Though a vesicular lung is not strictly air, yet compared with dense tubercular lung it may not improperly, for the sake of ready explanation and illustration, be regarded as such in this place. When the act of percussion is performed, a sound is produced which has usually been regarded as the sound of the wall of the chest, and when the sound has become dull from the presence of tubercle, the alteration has usually been acoustically explained by saying that the resonance in the lung is reduced in consequence of the diminution of the volume of air. It has been thought that the original wall sound has not been repeated and augmented by the consonating walls of the air cells and air tubes. This explanation may be accepted. Or, another, and, as it appears to me, a better and a simpler view of the case may be taken. We may regard the sound emitted on percussion of the chest, both in health and in disease, as the sound, not of the thoracic wall only, but of that portion of the whole chest immediately in the vicinity of the part struck, and comprising ribs, intercostal spaces, pleura, lung, and bronchial passages, together with their contained air. The healthy chest may be compared to a box or barrel, containing either air alone, or some light materials comprising in their interstices a large quantity of air, such as feathers lightly packed. The more air the barrel contains the more full and resonant will be the sound emitted when the barrel is struck with the fingers, as in the act of percussing the human chest. The sound will be what is termed clear, but I should propose to call it air-like, or an air-sound, as indicating at once its character and its cause. When the air is reduced in the barrel by a solid body, such as flesh or soft putty, or by a piece of wood being accurately fitted into it so as to fill it, the sound emitted on percussion is greatly altered. The sound is no longer what is called resonant. It has lost its air character, and has become dull, short, and flat. The change is due to the abstraction of air, and the sound now obtained is well described, and its character is accurately conveyed to the mind, and its rationale given, by saying that it has lost its air character. The air sounds emitted by a barrel containing air will vary in degree according to the quantity of air it contains, and so the human chest will emit air sounds in degrees proportionate to the quantity of air it includes. When a portion of the human chest contains no air whatever, as in empyema, in cancer tumours, and complete hepatisation, there will be an entire absence of the air sound on percussion.

When the flat or dull sound of phthisis is associated with adhesions of the pleura, the alteration is due in part to a tied down or bound down state of the wall of the chest and of the lung tissue immediately in contact with the adhering pleura. This bound down state produces the acoustic deficiency by opposing the freedom of vibration and the continuance of the vibratory act. That sonorous undulations in solids are opposed both in their extent and in their duration by mechanical constraint, is an acoustic law, and is readily proved by the following experiments:—Sound a tuning-fork upon a piece of wood, then hold it — i. e. the wood — pretty firmly, and the sound will be reduced both in loudness and in duration. Connect with each ear an air tube, supplied with a sound-collecting cup. Let one of these cups be pressed hard upon a table upon which a tuning fork is sounded, and let the other cup be held lightly. It will then appear that the vibrations conveyed through the firmly-held cup are weaker and less durable than those conveyed through the other. If one cup of my differential stethoscope be glued upon a table, or be connected with it by means of a thick tenacious body, such as spermaceti ointment; and if the other be held free, the sonorous undulations will be so very much stronger as conveyed through the free cup than through the other, that the sensation of sound seems to be procured exclusively through the agency of the ear connected with the cup that is held free, and not at all through the agency of the ear connected with the other cup fastened to the table. Percuss the upper surface of a chest of drawers, tolerably empty, in the middle; the sound emitted is an extremely air sound. Percuss towards the edge where the upper surface is nailed or glued to the perpendicular surface: the sound is now much less an air sound, and is short, acute, less loud and continued. When adhesions are present, the area of vibration is contracted in every direction. If we regard the rib, or the intercostal parts only, as affected by sound-impeding adhesions, we might say that the chord of vibration was shortened. In this case the vibrations are shorter, but they are more frequent. Hence the sound is, correctly speaking, more than usually acute, although, in ordinary language amongst physicians, the sound is said to be dull.

AMOUNT OF DEPOSIT THAT WILL SENSIBLY REDUCE AIR SOUND.—It is perfectly certain that every addition of tubercle or fleshy material to, and every reduction of air from, the contents of the thorax must tend to reduce the air character of the percussion sound. But it is nevertheless certain that the replacement of air by solid or fleshy material or by tubercle must be very considerable, and must bear a considerable proportion to the entire bulk of the lung lying immediately under the fingers, to produce a result that can be certainly appreciated and recognised by the ear. A few tubercles scattered through the middle or lower lobes of the lung in the proportion of one or two of the size of a garden pea to every half-square inch would effect no alteration in the percussion sound recognisable with any reliable amount of certainty. From numerous observations which I have made upon tubercular deposit and its associated percussion sounds, I am strongly of opinion that it is not until the air has been reduced one-third below its normal amount, that the alteration of the percussion sound in the direction of dullness attains to that degree that may with safety be relied upon. When the deposition and infiltration are such as to bring down the amount of air to one-half, there is recognisable a decided dullness, and when the air is all but absent or altogether banished, we have then absolute dullness, or that degree of dullness that is never exceeded on percussing any solid part of the body or the chest, under any condition whatever.

Dullness or shortness of sound on percussion may be, and often is to be, distinctly appreciated when the proportion of the deposit is exceedingly small to the entire pulmonary tissue, if that deposit be restricted to a part of the lung, small in extent and placed immediately under the part of the chest subjected to the percussion test. Thus if an amount of deposit altogether equal to not more than half a square inch be pretty well massed together, and be confined to a piece of lung immediately under the clavicular region, the superficies of which does not exceed three inches square, and extends no deeper than half an inch, a degree of dullness will be perceived which is at once made unequivocally obvious through the ear of the auscultator.

The dulling or deadening effect upon sound will be affected by the amount of vesicular air-containing lung behind the part percussed or beyond it. If such an amount of tubercle be present, as has been described above, in that part of the lung corresponding with the third interspace, a mass of lung containing the normal quantity of air may extend some inches behind the diseased part. In this case the dullness will be less than when the healthy lung lying behind the part which is percussed extends in depth only one inch, as may be the case at the apex of the lung behind the clavicle and above it.

A very small amount of tubercle will effect a material alteration of the percussion sound, will in fact sensibly reduce the air sound in one part of the lung when the same amount will produce no sensible alteration in another. When the entire extent of the lung concerned in the emission of sound on percussion is necessarily small, as at the apex which corresponds with the supra-clavicular, the clavicular, and the infra-clavicular regions in front, and with the supra-scapular region behind, a comparatively small amount of tubercle will suffice to curtail the air quality of the percussion sound. The apex of the lung at no part exceeds three inches antero-posteriorly, and not more than four inches from one side to the other, so that a small amount of tubercle will suffice to reduce by one-third the quantity of contained air, and consequently, from what has been ascertained as to the amount of reduction of air which will alter the percussion sound, to produce a sensible degree of dullness, or alteration of sound in the direction of dullness.

SEATS OF REDUCED AIR SOUND.—The earliest seats of reduced air character in the percussion sounds are precisely those selected for the primary deposit of tubercle. The favourite seat of tubercle in the first stage of phthisis being the apex, it is there that the percussion sound is first noticed as wanting or defective in the air character. It is extremely rare for the percussion sound to be altered in the manner described at the middle of the lung, or at its base, without the same alteration being perceived, and to a greater degree, at the apex, while it is extremely common, and indeed the ordinary rule or order of things, for the alteration to be recognised at the apex, when the ordinary sound holds in undiminished strength and integrity at all other parts of the lung. In almost all examples of phthisis excepting those which are of the acute character, the percussion sound is sensibly altered in character at the apex of the lung. If the supra-clavicular region be percussed, when tubercle has so invaded the apex as to reduce the contained air by one-third, and the patient be not so fat as to interfere with the act of percussion, and to prevent the blow reaching the lung, it is certain that an appreciable change in the air character of the sound will be recognised. It is here that the first approach to the dullness of phthisis is to be procured. If the patient be extremely fat we shall fail to obtain the change of sound so soon as at the clavicular or the sub-clavicular region, and particularly at the first and second interspaces, localities comparatively little loaded with adipose tissue. In most examples of tubercular disease of the lungs I have found percussion at the first and second interspaces more decisive of the presence of the peculiar deposit than at any other part. The materials interposed between the finger percussed and the lung tissue are at this point of greater tenuity than elsewhere, except in the axillary region, seldom exceeding in persons not absolutely fat the third of an inch in density, and they therefore interfere but little with the emission of the lung element or quota of the percussion sound. The alteration of the sound at this part in the first stage of phthisis is generally simply short, non-vibratory, and defective in loudness and in area, and comparatively seldom exceeds a considerable degree of dullness. Very great dullness or absolute dullness is very rarely an attendant upon the first stage of the disease, according to my experience, though I must confess that I have seen some few patients afflicted with phthisis, believed by other physicians to be in the first stage, in whom both great and absolute dullness have been observed. On careful examination of these patients I have satisfied myself that what was deemed the first, was really, as far as morbid anatomical changes were concerned, the third stage of the disease. I have almost invariably heard such other sounds from time to time, which in my opinion could proceed only from excavations,—it is true in a dry and comparatively silent state. Further, in such cases, marked by great or absolute dullness, there have generally been present unilateral depression and retraction, and very frequently that cardiac superficial impulse and that cardiac sound loudness which at a later period of this work I shall, I believe, be enabled to show are the almost certain signs of extensive destruction of lung tissue, by the process of excavation.

The part of the chest where the percussion sound is next most frequently observed to be altered in the first stage of phthisis is the mammary region. It is in the latter portion only of the first stage that decided alteration of the percussion sound is procured. When dullness, or an approach to it, is heard, then, in most examples of the disease, the lung at the apex is breaking up into cavernules*, or cavities, and consequently the dullness observed in the mammary region is less frequently an attendant upon the first than upon the second and third stages of the disease.

Alteration of the percussion sound in the direction of dullness in the first stage of phthisis I have seldom found to that extent that leaves no doubt of its presence in the mind of the auscultator, at the upper part of the posterior aspect of the thorax. It is well to percuss the suprascapular and the scapular and the interscapular regions in all cases of suspected phthisis; but manifest dullness will seldom be met with. Sometimes, but rarely, I have perceived a degree of dullness; but then the patient has been thin or very thin. The mass of soft parts and the scapula itself forming obstacles to the emission of lung sound, are the causes of the difficulty in these localities. It is in reply to strong or even violent percussion only that, in these parts, a dull or dullish sound is emitted, even when the subjacent lung is extensively studded with tubercles. I have, in a few cases, been enabled to satisfy myself of a degree of shortnes in duration of the percussion in the interscapular regions in the first stage of the disease, when, too, I have failed to obtain this sign at the scapular region.

The axillary region and the inferior lateral region are occasionally the seats of deficiency of air sound in the first stage of phthisis. In my own experience I have found these regions to be thus marked or affected in a very small per centage of cases of phthisis in the first stage, perhaps in not more than five per cent. In almost all examples of material reduction of air sound in these regions, I have heard the moist crepitation of the second stage, or the acoustic signs of dry or moist cavities, or of thickened and cicatrised obsolete lung structure, the quondam site of cavities, at the apex or apices, so that deficient air sound on percussion in this part of the thorax is very much more a sign of the second and third stages than of the first stage of phthisis, and is, therefore, undeserving of more notice here, as we are now concerned with the percussion signs of the first stage only.

Deficiency of air sound on percussion in the first stage of phthisis is occasionally found in the lower dorsal region. The rate of frequency is much the same as in the axillary and inferior lateral regions. Perhaps it is rather more frequently observed in this locality. The deficiency is heard to reach more commonly to a decided extent than in the lateral regions. Dullness of a decided character is more often found in the dorsal than in the lateral regions in the first stage of phthisis. I refer the more decided amount of deficiency of the air sound posteriorly to the fact, that the base of the lung, which descends more posteriorly than anteriorly, is more subject to hepatisation and serous infiltration than other parts. Most examples of decided dullness on percussion at the lower dorsal region in the first stage of phthisis, in my experience, have been signalised by pneumonia either in actual progress or but lately extinguished, or by the presence of some effusion consequent upon intercurrent pleurisy. Marked dullness in this quarter of the thorax has been noticed by me in numerous examples of phthisis, in what might be mistaken for the first stage, but which careful inquiry at the time, and post-mortem examinations afterwards, have proved to have been the third stage of the disease. The amount of tubercle must be very considerable in the subjacent lung to afford decided deficiency of air sound on percussion, for the volume of lung is large, and our acoustic experience informs us that a large amount of lung must have a large amount of solid matter deposited within it to have its percussion sounds decidedly altered in the direction of dullness.

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* This word is employed to express small cavities the size of peas and beans, produced by the expectoration of a few tubercles, and in contradistinction to cavities which occupy large portions of the lung.

It has been clearly established by the concurrent testimony of nearly all writers upon the physical examination of the chest in the first stage of phthisis, that for the most part this phenomenon of dull percussion, or an approach to it, is found as a rule at first on one side of the chest only. This restriction of the altered percussion sound to one side is almost without exception in chronic phthisis, which, as we shall afterwards see, is immensely more common than acute phthisis. In acute phthisis this restriction to one side is comparatively rare. Indeed, in this form of disease, the alteration of the percussion sound is generally ill-marked; and, like the distribution of its tubercle, is general throughout both lungs, apex, middle, and base alike included.

In a few examples of phthisis in the first stage, I have at my first examination found dullness at the apex of one lung, and at the base of the other.

When the altered percussion sound is not restricted to one side of the chest, examples of acute phthisis excepted, it is found that the alteration preponderates in a marked manner on one side in a very large majority of cases. While there is a decided dullness on one side, there may be only a certain shortness in the duration of the sound on the other, not constituting the usually accepted dull sound.

The little difference in the percussion sound of the two sides in the first stage of phthisis, slight at the first part of it, gradually becomes greater until a marked contrast is established. In chronic phthisis, the contrast is established in a striking manner at the end of the first stage, immediately prior to the breaking down of the lung structure, and by the deposition of inflammatory lymph and of binding exudation, and the formation of adhesions. This difference or marked contrast between the two sides forms a diagnostic point of great importance. When it is present, and when the characteristic features of other diseases equal to the change are absent, it is conclusive in almost every case of the presence of tubercle. So valuable is this sign, viz. the dullness or comparative or excessive dullness of one side of the chest, that all teachers enforce its importance upon the student. It is, therefore, carefully sought for as a very important element in diagnosis. The loss of symmetry, so to speak, in the percussion sound of the chest, as an evidence of grave disease, cannot be over-rated. Whenever it is present, there is grave disease either on the comparatively dull side or on the resonant side. It is more common to have disease on the comparatively dull side. Differential percussion is nearly as valuable as differential auscultation, but it comes to our aid later than auscultation.

But I am anxious to enforce the fact that long before a marked difference or contrast is satisfactorily established, a great amount of disease may be present and a very considerable deposition of tubercle may have taken place. It would therefore be most unwise and most dangerous to the interests of the patient, as well as injurious to the art of percussion, to conclude because no contrast can be made out that therefore the lungs are healthy or free from tubercular deposition. Not only do we not always find a reliable difference in the percussion sound of the two sides of the chest, in the first stage of phthisis, but in some considerable number of examples in the second stage, and in a few cases of phthisis even in the third stage, I have been unable to satisfy myself of the presence of unilateral dullness; though in nearly all examples, I have made out some of the earlier changes already noted and described as arising from deposition of tubercle and consequent reduction of air in the lung, and constituting the earlier manifestations of deficient air sound.

When the deposition of tubercle has taken place in equal or in nearly equal amounts at the anterior and superior portions of both lungs, the test of percussion is less reliable than when the deposition predominates in one lung. The alteration produced on the percussion sound being the same on both sides, the auscultator feels that less reliance can be placed upon its actually being the result of disease. The difficulty experienced is great on the part of the physician called on to pronounce whether the sound be that of a healthy chest or of one enclosing a tuberculated lung, when, in addition to a perfect uniformity of sound on both sides, the tendency to dullness is moderate. In such examples he must trust much to auscultation, and to symptoms, and to the history of each separate case. In the absence of the auscultatory signs of phthisis, and of the more decided symptoms and historical features, so to speak, of the disease, it would be rash to conclude that tubercle was present, for the thorax of many persons in health, as will presently be proved, emits a sound on percussion which is remarkably defective in air character compared with the thorax of others; and I have in not a few cases of tubercle present in a crude state, and also in a softened state, found the percussion sound to have more air character than in some persons in perfect health. I am also convinced that I have occasionally found the percussion sound of even the third stage of phthisis to be more of an air sound than that of some few persons in health, and when pneumothorax was not present to explain the occurrence. To account for this seeming contradiction we have two facts, one on the part of the diseased, and one on the side of the healthy chest. The unhealthy chest has been unusually resonant. The healthy chest has been unusually defective in air sound.

It is well, in judging of the value of the percussion sound, not to conclude that, in cases of phthisis, the side that emits the comparatively dull sound is necessarily the diseased side. When a vomica opens into the pleural cavity, and pneumothorax is established (a not unfrequent occurrence), the diseased side emits a resonant sound, compared with which the percussion sound of the healthy side is comparatively dull. One lung may be emphysematous to a greater extent than the opposite one; and in such a case the more healthy side will emit, upon percussion, a less resonant sound than the less healthy side. We must judge not only of the comparative sounds, but of the absolute sounds also. It is not enough to know the sound on one side is a little less resonant than that of the other side. If the less resonant sound does not possess in itself an absolute deficiency of air character denoted by shortness of duration, or increased pitch, or curtailment of vibration area, we are scarcely permitted to regard the lung beneath, from this evidence alone, as in a certainly diseased condition. In such a case we must seek for other signs, and particularly search on the more resonant side for the usual signs of pneumothorax and of emphysema. We must regard the absolute as well as the comparative resonance.

The necessity of attending to the absolute characters of the percussion sound is very necessary, if we desire to know the condition of a lung over which we are percussing. Percussion over the side opposite to that which is the seat of emphysema or pneumothorax ought to be made to aid in indicating not only the condition of the lung on the pneumothorax or emphysema side, but also on the other. If the percussion sound be unduly short in duration, defective in vibration area, and of high pitch, we shall be warranted in suspecting that the lung that is subjacent is in the first stage of phthisis. By attending to the absolute qualities of the sound on the more healthy side, we shall learn that tubercle is probably present on one and the more healthy side, and avoid having our knowledge restricted to the fact, that a penetrated cavity, or emphysema, exists upon the other. It occasionally happens, as will be shown when treating of the third stage of phthisis, that a peculiar air sound is obtained over a superficial cavity on one side, and that phthisis in its first stage is present on the other, which emits, on percussion, a comparatively dull sound. It will not be satisfactory to know only the condition of the lung on the resonant side, but by carefully attending to the absolute as well as the comparative qualities of the more dull side to ascertain the precise condition of the lung in this quarter, and to pronounce upon the presence of tubercular disease there also.

Dullness on percussion in health.—Many circumstances in respect of the patient, altogether unconnected with lung disease give rise to a kind of dullness, and it is very important to know what these are. A knowledge of these circumstances will explain the presence of a kind of dullness not unfrequently observed, and will serve to prevent the observer falling into the serious mistake of referring the dullness which attends them to the presence of tubercle or other lung disease. By the occasional, or even by the habitual, percussor, who is not very observant, the dullness due to the healthy conditions alluded to, may be undistinguished from the dullness of tubercle, and other pulmonary and pleural diseases. But, by careful attention, these two varieties of dullness may be distinguished, for they have peculiarities which once pointed out, and once fully perceived, will effectually serve in the diagnosis.

A large amount of fat under the integuments is one condition which gives rise to the dullness in question. I have met with many examples of impaired resonance from this cause. However, we often find a very considerable amount of fat upon the chest, particularly of adult females, without a decided approach to dullness being perceived. The muffling effect of the fat is very inconsiderable when the lung underneath is healthy and contains a large amount of air. If the percussion stroke upon a fat chest be slight, the muffling effect is greater than when it is strong, and for this reason, that the weaker blow operates chiefly upon the parts immediately under the finger, and fails to reach the contained lung in the same degree as the more powerful stroke.

A great development of muscle upon the chest,—of the pectoral muscles, the latissimus dorsi muscle, the intercostals, and the serratus magnus muscle,—goes a long way to create a kind of dullness. These muscles, when greatly developed, form a serious impediment to the percussion stroke reaching the lung. Much of the blow, if moderate, is spent upon the muscles, and is lost quoad the lung and air tubes, and therefore the sound emitted is defective in air character.

A very rigid and tonic state of the muscles, I have reason to believe, tends to the production of a kind of dullness. I have frequently noted the dullness referred to, particularly in robust young male adults accustomed to much muscular exertion, in whom I have been unable to detect any other condition equal, in my opinion, to the percussion result observed. The tense, intercostal, and other muscles seem to bind down the ribs, and the tensely grasped ribs and the tense muscles serve to check the free and continued vibration of the lung and its contained air. The vibrations of the parts are impeded and their duration is diminished.

The ribs, cartilages, and muscles, when rigid, are opposed to fullness of vibration. In this state the vibration of the lung and its contained air is impeded. Hence, in old age, we frequently find a dullness not natural to the young subject. The old thorax is less resonant than the young. The chief cause of this is the rigidity of the bone and muscle. The thinness or tenuity of the ribs, and the soft constituents of the walls of the thorax, and their great elasticity, in children, produce the remarkable fullness, extent, and duration of the percussion sound in these subjects.

It has appeared to me that a deficiency of air sound has been in some healthy chests due to a reduction in the antero-posterior diameter of the lung, dependent upon the form of the chest. Thus, in the case of the flat chest, in which the flattening is attended with a corresponding reduction of the antero-posterior diameter, the percussion sound is less resonant than in the case of the prominent chest, with a corresponding increase of the antero-posterior diameter of the lung. It is easy to suggest a reason why the sound should be more dull in the former case. The air element in the part percussed is less, and consequently the air element in the sound may be expected to be reduced. But it is to be observed that the flat chest is not uniformly or constantly more dull than the prominent one on percussion. In the flat chest it is not always the case that the antero-posterior diameter is small, nor is the prominent chest always attended with an increase of the lung in the same direction. The chest that is prominent in front may be hollowed behind, and, as it were, invade and reduce the antero-posterior diameter of the lung.

Another cause of dullness in the healthy subject is to be found in this fact—which is one that should not be forgotten: A given quantity of lung does not accommodate the same quantity of air in all persons. Some lungs seem to have more capacity for air than others; some can be made to hold more in the act of inspiration, and some usually retain more of a residuum, after ordinary expiration, than others. This is rendered manifest by measuring the expired air with the spirometer. When the lung is rather defective in its healthy property of inflating, or when it fails to retain the normal amount of air after expiration, a certain deficiency of air sound may be observed upon percussion. I am convinced that in not a few instances of defective air sound on percussion which have come under my observation, the fact was due to this cause, viz. an unusual, yet not what could be called an unhealthy, deficiency of air in the lungs.

The dullness on percussion proceeding from the causes now described is to be distinguished from the dullness proceeding from tubercle, by two series of facts, one relating to the absolute qualities of the sound itself, and the other to its locale. The sound itself in the case of the healthy chest never possesses that amount of dullness which we obtain from striking the muscles of the thigh. What has been designated as dullness, is rather a muffled sound. The sound emitted is devoid of that complete or marked character which indicates decided deficiency of vibrating area. It is seldom so short in duration as the percussion sound in phthisis. Increase of the force of the percussion stroke brings out an increase of air character, and produces a longer duration of sound, which is not the case in phthisis. This dullness, unlike that of phthisis, remains stationary, or, if the patient thins, tends to pass away.

The locale of the sound materially aids in the determination of the question, whether the dull sound observed is the result of the causes referred to, or of the presence of tubercle. The locale of the dullness in the first stage of phthisis is, as we have already noted, seldom symmetrical or general, and is, on the other hand, partial to an appreciable extent, and tends to become more and more non-symmetrical with the progress of the disease. This is not the case when dullness, or what is so designated, proceeds from the healthy chest from the causes under consideration, for it is perfectly symmetrical, and for the most part general over the entire thorax, superiorly, anteriorly, laterally, and posteriorly.

Dullness on percussion sometimes proceeds from disease, and yet from no morbid condition in any of the contents of the thorax. I have known dullness on percussion to be produced by morbid conditions exterior to the ribs. Thus I have noted partial dullness in the infra-clavicular region and the mammary region in some examples of carcinoma of the mamma. The dullness has not been confined to the parts actually covered by the disease, but has extended to the neighbouring parts, particularly those placed between the tumour and the humeral extremity of the clavicle. This dullness has been due at the locality of the tumour itself to the morbid mass impeding the extension of the blow to the lung, and to its obstructing the emission of sound from the lung. But at the other parts of the chest it has been owing to this, — that the integuments and external muscles have been so shortened and have been rendered so rigid as to compress the ribs and intercostal muscles so effectually as to injure them as vibrating bodies, and even to prevent the elevation of the ribs, and consequently the full inflation of the subjacent lung.

Contractions of the soft parts from other causes may produce similar results, and it is desirable to bear in mind that a decided local dullness may thus arise, and be altogether independent of the presence of tubercle.

The real dullness of phthisis is occasionally partially masked by extreme tenuity of the walls of the thorax. In some extremely emaciated subjects, the percussion sound over lung thickly incorporated with tubercle, acquires a certain air character to a large extent. But careful attention will enable the auscultator to distinguish this air-sound, short in area and in duration, from the air sound, full both in area and in duration, proper to the healthy and fully inflated lung. The diagnosis of the percussion dullness of phthisis in its first stage from that of other diseases requires careful attention. This is to be effected by attending to several series of facts. These are: (*a*) the absolute characters of the sound; (*b*) the locale and distribution of the sound; (*c*) the antecedents in respect of the health of the patient; (*d*) the present symptoms and condition of the patient.

The dullness in the first stage of phthisis is usually moderate. It consists, as has been already described, at its first development, rather of what is a shortness of area of vibration, a shortness of duration, than of what is properly speaking called dullness. If it be called dullness, it is more correctly designated comparative, and is by no means absolute dullness. The dullness of cancer of the mediastinum, of the lung, and of the bronchial glands, the dullness of hepatisation, the dullness of aneurismal and other tumours, and the dullness of empyema, is usually much more decided, and often reaches to what may with propriety be called absolute dullness. The dullness, too, of phthisis in its second stage is usually more marked than that of the first stage; and the dullness of the third stage, with few exceptions, reaches to an amount not ordinarily heard in the first stage of the disease.

The locale of the dullness of phthisis in its first stage has been already pointed out. While the altered sound in this disease chiefly holds at the apex, and, if not confined to one side of the chest, is more marked on one side than on the other, and is diffused over the whole extent of the supra-clavicular, the clavicular, and the infra-clavicular regions, the dullness of hepatisation is almost invariably discovered at the inferior dorsal and inferior lateral regions. The dullness of aneurismal tumours is usually situated in the centre of the thorax, embracing the region of the sternum, and invading the side of the chest to the extent of about an inch or an inch and a half, rather more frequently on the right than on the left. Cancerous tumours of the thorax, when attended with dullness on percussion, have this sign at its earliest development almost invariably marked at the sternum at the level of the second, third, and fourth ribs. It is usually restricted to this region, or it may embrace a small extent laterally on one or both sides of the sternum. In the advanced stage of cancer, when it involves the bronchial glands to a great extent and invades the lung tissue, the dullness will be found to grow in the direction of the mammary and infra-clavicular regions, directing its course from the sternum outwards. The progression of cancer-dullness is almost invariably on one side of the chest only. In my own experience cancer-dullness has been found more frequently on the right side than on the left. Tubercular dullness has been found by me nearly as often on one side as on the other.

The dullness or percussion of other mediastinal tumours is, of course, confined at first to the sternal regions and to their lateral borders. I am not aware that it is found invading one side of the chest more than the other.

The dullness of hydrothrorax is generally found at the base of both sides of the chest. It may preponderate on one side, and in some examples of this disease, or this result of disease, it is strictly confined to the base of one side of the chest. When, as is most frequently the case, the effusion is the result of cardiac disorganisation, the dullness is occasionally found on one side, or more upon one side than the other.

THE ANTECEDENTS OF PHTHISIS AND OTHER DISEASES CAUSING DULLNESS ON PERCUSSION.—In phthisis the antecedents are most commonly, or almost invariably, the gradual, moderate, and steadily increasing loss of strength; the accession of lassitude; the loss of flesh, as discovered by the weighing machine or by the eye; a moderate amount of shortness, quickness, or embarrassment of respiration, most observed during exertion, as in walking, during manual labour, or while going up stairs. The pulse had been previously quickened, some flushing of the face, and heat of skin had been observed, more particularly in the evening, and succeeded in the night or early morning by perspiration. The skin had previously become dry and rough, and the hair of the head had been observed to fall off. Hæmoptysis had probably occurred, at first suddenly and to some extent, perhaps amounting to some ounces, and had recurred at intervals in minor quantity, mixed up with frothy sputum. The expectoration had been increased to an abnormal amount and had continued to augment, and had been sometimes frothy, and sometimes green and yellow, tenacious and tremulous, and homogeneous. There had been frequent short cough, or less frequently a long, deep, loud cough, seeming to proceed from an irritation lower down in the aerating apparatus than the larnyx, the trachea, or the primary bronchi. Whatever pain had been experienced in the chest had been vaguely situated, now in the region of the clavicles, now at the shoulders, and at another time in the lateral regions. The pain had not been acute, or only seldom so, and had partaken largely of the character of aching. In acute phthisis the accession of the cough has been sudden; the respiration has been early quickened; the pulse has soon become fast; pains of a somewhat acute character have been experienced, for the most part in the sides; the heart's action has been visibly increased; the expectoration has been copious, of a tenacious character, yellow or green in colour; and crackling in the chest and trachea have been heard proceeding to the ear of the bystander through the intervening atmosphere. These symptoms have been accompanied with chills, and flushing, and copious sweats, much frequent cough, and restlessness. The tongue has been coated and the appetite has been impaired, while thirst has oppressed the patient. He has probably evinced signs of the strumous diathesis; or he has, within the preceding few days or weeks, suffered from long exposure to cold, or from an attack of measles or small-pox, common exciting causes of pulmonary tubercle.

The antecedents of hepatisation are, exposure to cold, or the suffering from some febrile disease, such as typhus fever or scarlet fever. The attack was sudden, accompanied with pain confined to one side, or it might be in both; short painful cough, accompanied with remarkably tenacious, rather clear or greenish sputum, becoming in a few days rusty coloured. The respiration was quickened and painful; the face flushed continuously; the pulse quick and full; and the tongue dry and coated. A hot, dry condition of the skin; it might be partially succeeded for an hour with free sweatings; and occasional delirium would be present. The acute conditions would last only some days, and rather suddenly give way, leaving some shortness of breath, cough, and some sputum, gradually declining.

Empyema dullness is associated with an antecedent history very different from phthisis. The onset of the disease was acute and sudden, and attended with sharp pain and difficulty of respiration; the patient seeking the semi-recumbent posture. The disease began on exposure to cold, or supervened upon scarlet fever or acute rheumatism; and pyrexia symptoms were manifested for some days, and then rather suddenly declined, leaving embarrassment of respiration when the patient lay upon the side opposite to the one affected. The cough was frequent, short, and painful, and accompanied with very little or no sputum.

Mediastinal and aneurismal tumours have had their dullness on percussion beginning near the sternum, and sharply bounded by resonant percussion sounds more externally. A sense of distress has been present at the sternum, often accompanied with pain; there has been absence of febrile symptoms, and the complaints of the patient have been more localised. Sometimes a difficulty of swallowing has been experienced, and great embarrassment of the respiration has been felt at the region of the sternum. The bronchi being pressed upon, the respiratory sounds and the cough have had a constricted tube character. The cough has sometimes had an *extremely* constricted sound, originating not in the throat, but in the chest. The respiration sounds have, in some cases, had the character of air passing with vehemence through a gun barrel. In cancer of the mediastinum there has been a gradual decline of strength and flesh, and the sputum, sometimes sanguineous, has been moderate. In the case of aneurism, the heart's action has been embarrassed, and often tumultuous; the veins of the front of the chest and of the neck have been full; and though the breathing has been affected, the cough has not been severe, but dry; and hæmoptysis, when it has occurred, as it sometimes does, in such cases has been at long intervals and to a considerable amount. When cancer has invaded the adjoining borders of the lung the sputum has become coloured like prune juice. The presence of œdema, at first locally and then generally, at an early period of the disease is frequent, when dullness depends upon the pressure produced by aneurismal tumours.

The dullness of percussion in hydrothorax has been very frequently attended with palpitation of the heart, and with other signs of disturbed cardiac action. The difficulty of breathing has been greater and more constant in hydrothorax than in phthisis in the first stage; and the elevated shoulders during sleep have been early noted in the case of serous effusion.

D. The present symptoms prove of great value in deciding whether the dull sound on percussion be due to phthisis in the first stage, or to other morbid conditions.

While in phthisis the face becomes sharp, and varies rapidly from pallor to flushing, in hepatisation it is comparatively calm and of uniform colour. In empyema it is anxious, drawn, and indicates suffering; in hydrothorax it is generally rather livid and full, and in aneurismal tumours it may be tolerably healthy, with only a slight amount of puffiness. In cancerous tumours the face is usually pale or sallow, and wasted.

The respiration in phthisis is only moderately affected, while in hepatisation it is more decided, and in empyema and hydrothorax, and in cancerous and other tumours of the mediastinum, it becomes excessive, and forms a leading feature in the case.

The action of the heart in phthisis is quickened, while in aneurismal tumours and hydrothorax it is laboured, diffused, and troublesome to the patient, and gives rise to an irregular or intermittent pulse. In empyema of the left side, the heart is more or less displaced towards the right side of the chest.

In phthisis, the condition of the patient is marked in an especial manner by wasting of the whole body, slow and steady, and bearing a large proportion to the distress in the chest; while in empyema, cancer, and mediastinal tumours, the local distress is in excess of the general wasting and disturbance.

The cough in phthisis is more marked than in other diseases accompanied with dullness, and the sputum is more continuous and uniform, and is associated more frequently and more constantly with hæmoptysis, for the most part moderate, but occasionally pretty copious.

Different varieties of percussion sound have been noticed by different authors in the first stage of phthisis. It has been usual to divide the altered percussion notes of commencing phthisis into dullish, dull, and very dull. My friend, Dr. Cotton, speaks of a dullness which he designates as wooden; but it appears to me that this is too vague a character, for wood will give out almost any sound according to its size, its thickness or thinness, the quantity of air beneath it, and the distance of the air from the percussed surface; also according to the hardness of the wood, and to its firmness or looseness in respect of its subjacent body; and it is obvious that each kind of sound so obtained is equally entitled to the designation of wooden. The wooden sound of Dr. Cotton is one of considerable dullness, not absolute dullness; it is of short duration, and harsh to the ear. The wooden sound is usually employed, I believe, to denote a sound such as proceeds from a short thick piece of wood. If used in this restricted and defined sense it may be useful.

Absolute dullness is occasionally heard in the first stage of phthisis, but it is confined to the inferior and posterior aspect of the chest. It is duller than the dull sound. It is nearly imitated by striking the second phalanx of the forefinger of the left hand with the forefinger of the right. The struck finger is held free in the air. It is due to complete solidification or effusion in the pleura.

Some physicians have, in a few instances, believed that they have heard the sound termed by the French bruit de pot felé, or, by the English, cracked-pot sound, in the first stage of phthisis. I have never heard this sound at this stage of the disease; and I feel assured that the sound, in its true and full characters, has never been emitted by a chest in the first stage of phthisis only. A sound, which may be called a quasi-cracked pot sound, it is true, is occasionally heard. It is a sound, loud, not dull, prolonged, with a metallic-like slight chink; but the peculiar dull, loud, jarring, short duration, cavity clink is different from it, and by the practised and careful physician may be readily distinguished from it. This quasi-cracked pot sound will be considered more, and contrasted fully with the true sign, at later parts of this work. The quasi-cracked pot sound is heard most frequently in the case of children; and whether the contents of the chest be healthy or unhealthy seems to have little influence in its manifestation according to some of the most copious writers on the subject. It is of no value whatever as a sign of the first stage of phthisis.

CHAP. XII.

FIRST STAGE—*continued.*

Position and Form of the Chest. — Forward Inclination of Thorax.—Rounding of Back.—Elevation of Clavicles and Scapulæ.— Double-flattened Chest. — Single-flattened Chest. — Depression of the Thoracic Cone.—Angular Conditions of the Front of the Thorax.—Varieties of Chest in reference to Induction of Phthisis.

CONSIDERABLY before any appreciable alteration in the position of the chest in phthisis can be discovered, the auscultatory signs and alterations of the percussion note which have been already described, are manifested in a sensible and reliable degree in almost every example of the disease. But ere much time has passed from the accession of dullness on percussion, the position of the chest undergoes a change in a large proportion of cases. I am inclined to say that not less a proportion than one half of patients in the first stage of phthisis in whom a reliable degree of alteration in the percussion sound is procured, evince, in an amount sufficiently great to be appreciated, a change in the position of the chest in respect of the perpendicular. The thoracic cone is bent forward at an abnormal angle. The axis of the thorax is no longer a continuation of the axis of the abdomen, or nearly so, as in health, but is inclined forward to a sensible extent. This is obvious to the eye. The shoulders are carried forward with the thorax. If one limb of the chest goniometer (an instrument to be afterwards described) be applied to the lumbar vertebræ, and the other be applied to the dorsal vertebræ, or in the direction of these bones, the arrow of the index will point not to 180°, the normal point, viz. that of a straight line, but to 175° or 160° upon the arc.

The dorsal vertebræ, from a comparatively straight line, deviate to a curve constantly increasing with the progression of the disease. This may be measured with the chest goniometer. We take the tangents to the curve. A portion of the vertebral curve is taken about equal to the length of the two extended arms of the instrument, this being divided into two equal parts, the two limbs respectively placed upon these parts give the tangents to the curve, and by looking at the index on the arc, we find that the angle formed by the meeting of the two tangents is that of 180°, or even 150°. Thus we measure the amount of the curve, and consequently the amount of deviation from the normal line or form. In this way we have a mathematical and exact demonstration that the curve of the dorsal vertebræ is materially increased. The back is become rounder. It will be found, however, at a future part of this work, that the increased curve of the first stage of phthisis is replaced in most examples of the disease, and more particularly in chronic cases with excess of dyspnœa, by a very great increase of roundness in the third stage of the disease. It appears to be scarcely necessary to say that this undue curving of the dorsal vertebræ occurs in other diseases, and in cases of mere general debility long continued.

Concurrent with the rounding of the dorsal vertebral line, the clavicles and scapulæ are wont to be unduly raised, but to a very small amount in the first stage of phthisis. This holds only in perhaps fewer examples than the rounding of the spine, and it is remarked most when the first stage is considerably advanced, and when both sides of the chest are affected; or when in addition to the apex or apices being tuberculated, one or both bases are congested, or have their finer bronchial tubes obstructed with thickening of the mucous membrane, or with excessive secretion. In such cases an explanation of the greater frequency of this alteration in the shape of the thorax is found in the presence of more than usual dyspnœa. The elevation of the clavicle and scapula is moderate, and much less extensive, and less frequent than in asthma.

The most common alteration of the configuration of the thorax, in the early part of the first stage of phthisis is a flattening of the anterior surface. The flattening involves the sternum down to the ensiform cartilage, and the cartilages of the first four or five upper ribs on both sides of the chest. The sternum, instead of presenting a projecting line as it descends, tends to become perpendicular, or it may even incline inwards as it passes down. If the joint at the middle of the chest goniometer be placed at the upper border of the sternum, and one limb be directed upwards, but in the perpendicular, and the other, or as it will now be the inferior, limb be placed upon the sternum, the index on the arc will point to 180°, or, so to speak, to the angle of a straight line or to a smaller, viz. 175° while in health the angle indicated would be 190° or 200°, the latter indicating a well projecting sternum. The cartilages of the ribs are flattened laterally, the normal rounded figure of health is lost. The angle of the tangents to the curve will frequently be found 178°; or within two degrees of a straight line, while it is to be remembered that the normal angle in most adult chests is about 170°. But it is not laterally only that the flattening is remarked, or that this holds with single cartilages only; the same alteration is visible vertically or from above downwards in reference to the line formed by the aggregated cartilages. In health the line which represents the cartilages from above downwards is rounded or curved and the angle of its tangents most commonly is about 170°, while in the first stage of phthisis it often becomes straight or perpendicular, or it may even be directed inwards towards the spine as it descends, being the reverse of the natural direction. The angle to its tangents is often 178° or only two degrees different from a straight line. The second, third, and fourth cartilages suffer more flattening than the first and the lower cartilages, and hence the inclination to the straight line which we observe. When the sternum has assumed the perpendicular direction, and the costal cartilages on both sides of the chest have became flattened, I have designated this abnormal alteration the double flattened chest. This deviation from the natural configuration of the thorax is very common in the first stage of phthisis. It has been observed by me in a large percentage of examples of phthisis at this period. It is peculiarly the deviation of the more early period of the first stage of the disease. Of sixty-six examples of this alteration occurring in phthisis of which I took particular notice, forty-nine were associated with the first stage, twelve with the second stage, and five with the third stage. It is a comparatively rare occurrence in other diseases. Of seventy-four examples, as many as sixty-six occurred in phthisis, and only two occurred in bronchial disease, one in dyspnœa and two in heart disease. To account for the comparative rarity of this deviation in the advanced stages of phthisis, it is to be remarked that this is not due to a subsequent rising of the sternum and rounding of the costal cartilages, but to the fact that more remarkable and striking deviations of a restricted extent occur in these stages and take the place, so to speak, of the double flattened chest, these deviations being single flattening and undue angularity of the articulations of the sternum and cartilages, and of the cartilages and the ribs. The double flattened chest has been more frequently observed by me in females than in males. The rate per cent in males has been only 39·1 per cent., while in females it has been 60·8. This preponderance amongst females is due perhaps to the greater delicacy and feebleness of this sex, which tend to habits of stooping, to early yielding of the ribs and cartilages to the injurious influences of the disease, and also to the fact, of which I have no doubt, that phthisis in females is less frequently than in males the result of active accidental causes, and more frequently the product of constitutional errors, slow in operation, and therefore more likely to be attended with general debility. The disease for the same reasons is more likely to be diffused over both sides of the chest and to lead to a corresponding flattening. This deviation from the natural configuration of the chest occurs at all ages, but is remarked in a larger proportion of cases in young subjects than in old. I have observed that the proportion of examples is excessive in girls under fifteen years of age. The greater ratio of cases in the young than in the old probably depends upon the more yielding consistence of the bones and cartilages in them than in adults.

The double flattened chest is not confined to phthisis affecting both lungs. It is seen occasionally when the physical signs reveal, by reliable evidence, the presence of tubercle in one lung only. I have seen double flattening nine times in single phthisis out of forty-nine examples of this deviation in the first stage of phthisis. In the other forty examples the tubercle was diffused over both lungs, though it is true in some cases the deposit preponderated much on one side over the other.

The double-flattened chest owes its development to the reduced bulk of the lung. Although the weight of the lung in phthisis increases materially by the deposition of tubercle, yet its bulk, under the inspiratory effort, is very considerably reduced, The accession of fresh and adventitious material interferes with the normal inflation of the vesicular structure; an amount of air is prevented entering, greater in bulk than the obstructing tubercle that is added; and the result is a decided diminution in the bulk of the lung, even during inspiration. The normal quantity of retained air is likewise reduced by the presence of tubercle, and consequently the bulk of the lung, even after expiration, is also diminished. As soon as the lung is inflated to that degree that cannot be exceeded without pain, distress, or laceration, or undue distension of dilatable parts, the inspiratory muscles which elevate the chest, including the sternum and the ribs with their cartilages, in inspiration, cease to act. This point or limit of easy inspiration must be reached sooner when the lung is solidified by tubercle, than when it is fully inflatable as in health; and therefore the chest will rise less in this disease than in health. As the sternum is less raised, it will, of course, project less, and as the cartilages are seldom *elevated*, interstitial absorption will soon remove these curves and impart the flattened appearance which is under consideration. To this cause is frequently super-added another, viz. the presence of contracting tissue in the lung, underneath the upper cartilages. Plastic tissue, either in the lung or at the pulmonary pleura, by contracting very much, destroys the vesicular structure, and compresses it to a great extent. Over this part, of course, the chest cannot rise without the occurrence of a very unlikely amount of compensatory dilatation in other parts, or of laceration. If to such plastic material there be added fibrinous exudation, binding the pleura pulmonalis with the pleura costalis immediately under the cartilages of the upper ribs, a great addition is made to the means by which flattening is produced. This fibrinous bond is observed in many examples of phthisis in the first stage, but much more frequently in the latter part of it than in the first. Soon after its formation, it contracts, and by a process of traction it suffices to drag down the cartilages, the ribs, and the intercostal soft parts sometimes to a striking and remarkable extent.

When tubercle is present in both lungs, it seems to account for the presence of flattening on both sides, upon the principles above described; but we have seen that this deviation is peculiarly the deviation of the first stage, and even of the first part of it; while we know that in a large majority of cases of phthisis, the disease, when first noted, is discovered to be confined to one side. In the case of flattening on two sides when only one lung is tuberculated, we require to know what agency induces the deviation on the healthy side. The explanation is perhaps to be found in this—that the chest is not only in health symmetrical in form, but in muscular action, and that even in disease it is some time before a loss of symmetry of muscular action can be established. The ribs over the unhealthy lung are not duly raised, and as the muscles on both sides have hitherto acted in unison, the muscles on the healthy side decline to act longer or more fully than those on the unhealthy side, and hence a flattening which owes its origin on one side to non-inflatability, is matched on the other side with a flattening, the same in appearance, and much the same in extent, owing its origin to a different cause, viz. deficient muscular action. The muscular default is due to diseased lung on one side, and on the other to the loss of that harmony which tends to hold in all symmetrical organs. The lung on one side does not inflate fully, and the lung on the other cannot: the ribs on one side do not rise, and on the other they cannot.

The double flattened chest is not of great value in the diagnosis of phthisis, for it is not unfrequently found when there exists no tubercular disease, and occasionally when there is no thoracic disease whatever. It is occasionally present in chronic bronchitis, and I have seen it in one or two examples of albuminous infiltration of the apices of the lung from over-vascular action, causing devesiculation of the parts. This configuration of the chest is sometimes congenital, very often it is acquired by occupations entailing long continued bending forward. Its value is as nothing in the diagnosis of phthisis, compared with the revelations of the stethoscope and of percussion. Nevertheless it is not without some value as an adjunct to these sources of evidence.

The single flattened chest, as an indication of phthisis in its first stage, is of far more value than the last deviation, and is really useful. We find that the single flattened chest is generally the accompaniment of serious organic pulmonary disease. A few examples of this alteration of the chest are found without any organic disease, and are dependent upon congenital conformation, or more frequently upon the influence of occupation in trade, or upon lateral curvature of the spine, but the proportion which these cases bear to examples of well-defined flattening on one side dependent upon phthisis is small and they admit of very ready reference to their proper category. The single flat chest is more rare in the first stage of phthisis than the double flattened chest. While six examples of double flattening were seen in twenty cases of incipient phthisis, only three, or just one half of single flattening examples were found in the same number of phthisical cases in the first stage. Obvious single flattening is not restricted by any means to the first stage of phthisis, although it is common to it, for it is more frequently met with in the third stage than in the first. Thus I ascertained the presence of this alteration of form was found twenty times in the third, and only thirteen times in the first stage out of forty examples occurring at all periods of phthisis. In the second stage this deviation was found seven times only out of these forty examples.

The diseases besides phthisis in which single flattening occurs may be partly learned from the following table of seventy-four examples which I have analysed.

Phthisis.	Doubtful Phthisis.	Bronchial Affections.	Dyspnœa.	Heart Disease.
66	3	2	1	2

Since this table was made up, I have found a remarkably good specimen of single flattening occurring in cancer of the right lung. The flattening was very decided, the percussion was extremely dull; the respiration sound was blowing or large bronchial, but the voice was weak. The patient was an adult male, and was seen in the hospital. I had not met with such an amount of flattening previously without making out the presence of a tubercular cavity, nor have I met with such another example since. Within the last three weeks (Dec. 31, 1860), I saw an example of flattening of the right side, accompanied with very dull percussion at the right base, and strong large tubular constrictive blowing above.

A cooing systolic murmur at midsternum caused me to suspect aortic aneurism.

The single flattened chest is occasionally attendant upon hepatisation of the lung, but when so occurring, it is associated with very considerable retraction of the middle and base of the thorax, so that the distinction is easily made.

This alteration in phthisis is frequently associated with a moderate amount of flattening on the healthy side, but this bears so small a proportion to the alteration on the unhealthy side, as to warrant us in saying that the morbid condition of the form of the chest is one of single flattening. The flattening or depression is so conspicuous, and contrasts so much with the opposite side, as to attract, so to speak, the exclusive regard of the eye, or rather of the mind, through it. This single flattening is frequently superadded to the double flattening which had existed at a previous period of the disease. More deposition of tubercle and consequent non-dilatability of lung have taken place; and, in addition, contractions of exuded plastic materials at the surface of the apex of the lung have compressed the vesicular structure, and led to the descent of the anterior and superior parts of the walls of the chest, both hard and soft.

The flattening upon one side of the chest is frequently seen on one side, while the full curves of the other side are still present.

This seems to happen when the disease has been rapid, and when much pleuritic inflammation has been present, by which much traction power has been exercised within a period too short to admit of flattening on the other side, or when the respiratory necessities of the blood have demanded as full an inflation of the healthy lung as was possible.

Instead of flattening of the opposite side taking place, I have sometimes seen an amount of fullness and curving which has looked like a compensatory change, but this has been observed very seldom in the first stage of phthisis, and much more frequently in the third. Indeed I am not quite certain that a very decided flattening on one side and a fullness on the other are not, almost without exception, the associated conditions of phthisis confined to one side in the third stage; but as I shall have to treat of the third stage at an after period, I shall hope to find an opportunity to refer to this point again.

The mechanism of single flattening is much the same as that of double flattening. It is the result of more local influence, of more intense action of the causes of the previously described change, and of the more potential local operation of fibrinous or plastic exudation. The depression or flattening is confined to the costal cartilages upon one side, with the occasional exception above noticed. Sometimes the flattening of the costal cartilages is associated with a deflection of the sternum from its normal plane. The sternum in this case inclines by its lateral border to the depressed costal cartilages, and makes, or tends to make, with the longitudinal line of these bodies, one straight line. Instead of the transverse line of the sternum observing the transverse line of the body, as in health, it is oblique in its direction, slanting to the diseased or depressed side. When this occurs, an abnormally angular state of the sterno-costo cartilage articulation of the healthy side is produced. But this is much more frequently associated with phthisis in the third, than in the first stage.

Another deviation from the natural configuration of the thorax which is met with in the first stage of phthisis, is a depression of the whole of the upper ribs for the most part, chiefly the first three; the depression holds from the points of attachment to the sternum and the vertebral column, and becomes more manifest at the outermost parts of the ribs, those most distant from the attachments referred to. In this case, the depression attracts notice chiefly when the deviation is confined to one side, and the alteration is made very manifest to the eye by its being associated with a corresponding depression of the scapula and the clavicle. Instead of the line of the clavicle being, as in health, horizontal, or nearly so, it takes a downward inclination as it separates from the sternum. The line of the clavicle may make with the horizontal line an angle of 10° or 15°. It is to be observed that this kind of deviation occurs much less frequently in the first than in the third stage of phthisis, and that it is very commonly the result of hepatisation of the lung, and also of lateral curvature of the spine.

An inordinately angular condition of the articulations of the sternum and the upper costal cartilages, and of the costal cartilages and the ribs, is also not uncommonly seen in the first stage of phthisis. It is sometimes observed on one side only, and sometimes on both sides. When on one side only, it is of rather more value, as an indication of the presence of phthisis, than when seen on both sides: of twenty-two examples, nineteen were associated with phthisis, and one with doubtful phthisis. When on one side only, there is generally present tubercular disease on the distorted side. This abnormal angularity is generally only very moderate in degree in the first stage of phthisis, and it increases in the second and third stages, often to a very remarkable extent, as we shall see when we are occupied with these stages. When this angularity is seen on both sides of the chest, tubercle, when present at all, is usually found on both sides of the chest. Of ten examples of double angularity which I analysed, eight were associated with tuberculated lung, and in three of these eight cases, the disease was in its first stage.

This angularity I have observed to occur at all periods of life. Young subjects have presented many of the examples of this deviation, and females have shown it in a great proportion. Possibly the weaker condition of the articulations in females and young persons may conduce to this result.

I have occasionally seen the abnormally angular articulations of phthisis greatly enlarged and tender to the touch, from the presence of inflammatory action, evidently the result of undue stretching of the parts. I have also known pus to form at such articulations.

At the conclusion of this work I have added a paper on this subject, which I published in the "Archives of Medicine." It contains some wood-cuts.

It is a common subject of belief amongst the public, and perhaps also of a portion of the medical world, that deformed and narrow chests more frequently enclose tubercular disease than the healthy and capacious. My examination of some six thousand nude chests at the Consumption Hospital has established several facts in connection with this subject. The first is this: — Comparatively few greatly distorted chests are seen amongst phthisical patients; I believe not more in proportion than are found in persons not suffering from phthisis. I have met the greatly distorted chest, the greatly gibbous back and sternum of rachitis, in not more than some six persons suffering at the same time from decided phthisis; while amongst this number of six thousand, I have seen this distorted chest in at least some dozen suffering from some dyspnœa and bronchitis. The finest specimens of the human thorax I have constantly seen associated with tubercular disease of the lung, and I believe that persons having this development are not materially less liable to phthisis than others.

It is true that the chest in phthisis, as we have just seen, particularly when the disease is advanced, is the frequent subject of alteration of form and of abnormal deviations; but this is generally partial or local, and it is the result, and not the cause or adjuvant, of phthisis.

Out of forty patients, male and female, now under my care in the Hospital for Consumption, I happen to have three examples of abnormally formed chests, not the result of disease of the contained organs. Two females, about forty years of age, have greatly deformed chests from angular curvature of the spine; and one male, about thirty years of age, has a highly developed pigeon-chest, or gibbous sternum. The man suffers from bronchitis. One woman has humoral bronchitis, and the other woman has general dry bronchitis, characterised by much sonorous rhonchus. I am inclined to think that this latter patient has a small cavity of a tubercular character on the right side, surrounded by condensed and contracted pulmonary structure. I am led to think there is a cavity from the presence of very decided dullness of the percussion sound, and from the strong and little muffled thoracic voice, and from the superficial and decided impulse of the heart, seen and felt at the second right interspace. There is little motion of the right side, and the percussion is dull below. But my colleague, Dr. Cursham, is of opinion that the case is chiefly one of bronchitis.

CHAP. XIII.

FIRST STAGE — *continued.*

Movements of the Chest.—Deficiency of Motion.—Increased Raising of Shoulders and defective Expansion.—Stethometers.—Defective Motion at Base of Chest: How distinguished from that of other Diseases.—Compensatory Motion of healthy Side.

The movements of the chest in the first stage of phthisis are frequently the subject of obvious alteration from the healthy condition. While the number of respirations in a given time are increased, while the diaphragm may descend more than natural, and the expiratory muscles may evince increased effort, it is manifest that the elevation of the upper ribs, in their healthy manner, is reduced; that motion of the ribs, which is, so to speak, individual or special, and different from that motion which is owing to a lifting of the whole thorax in dyspnœa, is certainly reduced in the first stage of phthisis. In the act of inspiration we observe that though the ribs be lifted they advance less forward, and expand still less laterally than natural; there is less free motion of the individual ribs upon the points of their attachments to the vertebral column and the sternum. There may be considerable elevation, but the expansion is deficient, little outward movement takes place, and all the ribs are lifted together, and more as one piece, than is usual in health. Whenever there is that amount of deposition of tubercle which impairs, to a material amount, the inflation of the upper lobe of the lung, the deficiency of motion of the upper ribs is to be observed. It is to be borne in mind that as an amount of tubercle may be present, perfectly constituting phthisis, and giving rise to serious derangement of the health, to wasting and hæmoptysis without an appreciable deficiency of respiratory sound, or to dullness, so there may be the same condition in respect of tubercle without an appreciable deficiency of motion. This deficiency of motion is often very marked in the latter periods of the first stage, but it becomes greatly more developed in the second and third stages of the disease. The deficiency of motion is generally confined to the ribs placed over the diseased lung. When decided in amount, we may conclude that serious disease is underneath, and that, if the percussion sound be moderately reduced in air character and duration, that the malady is very probably of a tubercular character. It is to be borne in mind that deficiency of motion, like deficiency of inspiration, may be due to disease of the muscles of the chest, of the integuments, and of the ribs themselves, as when they are the subject of cancer; but this latter condition will be at once evident to the eye. The eye will suffice to detect a deficiency of motion, but the hand will often conveniently corroborate the observation. I believe that the eye alone will detect deficiency sooner than some of the stethometers which have been contrived to measure the decline of the thoracic movements. The deficiency tends to grow as phthisis advances. The stethometers of Dr. Quain and Dr. Sibson are useful in ascertaining and recording the increase or decrease of this morbid state, and they suffice also to afford an illustration and proof of the defect that may satisfy some minds more than the unaided inspection of the chest itself.

We have spoken above of defective motion of the walls of the thorax as confined to the upper ribs and cartilages. It remains for me to say that in a small proportion of cases of phthisis, even in the first stage of the disease, there is observed a deficiency of expansion of the ribs placed over the base of the lung. The inferior lateral is the region in which this defect is most marked. The ribs there lose their outward expansion. The ratio of cases in which this deficiency has been recognised, to the whole number of cases of incipient phthisis which have come under my care, is about one in twenty cases. In almost all these cases of deficient motion the disease had progressed to an advanced period of the first stage, and had been associated with deficiency of motion of the upper ribs. The deficiency of motion here depending upon tubercle, or tubercle and associated pneumonia, may be distinguished from mere hepatization by the healthy state of the upper lobes of the lung in the latter disease. The deficiency of motion of the first stage of phthisis in this region is to be distinguished from the immobility of pneumothorax by its associated moderate retraction, and reduction of dimension; and by the presence of tympanitic percussion sound in the latter disease or accident. The deficiency of motion in emphysema is observed on both sides of the chest, and is attended with clear percussion, and with whistling or cooing rhonchi. With respect to deficiency of motion at the upper part of the chest in incipient phthisis, it is to be observed that it is, unlike the deficiency of motion, independent of disease, seen chiefly on one side, and that the percussion note with which it is associated is dull, or short in duration, and that flatness of form frequently accompanies it. The respiration sounds in phthisis are such as have been already noted: in emphysema they are whistling and cooing, and very protracted, particularly the expiratory. The loss of motion of pneumothorax is combined with deficiency or total absence of proper lung sounds, which are replaced by amphoric blowing, more or less loud, and more or less constant, and with metallic tinkling. The deficiency of motion at the base when dependent upon effusion within the pleura, is distinguished by increase of dimension at first, by rapid variation of dimensions, and by gradual decrease as absorption proceeds. Effusion is also generally at first denoted by the presence of ægophony, and by very great deficiency or total absence of, or quasi-remoteness of respiratory sounds, and further by absolute want of air character in the percussion sound, which in fact resembles the percussion sound of a finger held in the air and struck by another finger.

It is not unfrequently observed in phthisis, at its first stage, that the clavicles and scapulæ are unusually raised in inspiration, while the larynx is preternaturally drawn to the thorax, and there is much abdominal movement from more than usual descent of the diaphragm, common in cases of great consolidation and laryngeal disease. In a very considerable proportion of examples of phthisis in the first stage marked by defective motion on one side, the diseased side, the movements on the opposite side are greater than is usually observed in persons in health. This is observed chiefly at the upper front and in the lateral regions. This increase of movement is a compensatory one.

CHAP. XIV.

FIRST STAGE—*continued.*

Dimensions of the Chest.—Reduction of antero-posterior Diameter.—Increased Semi-diameter from Effusion.—Reduced Semi-diameter.—Increased Semi-diameter from Hypertrophy of Lung.

The dimensions of the chest in the first stage of phthisis are not altered when the organic disease consists only of a few scattered tubercles, the size of, say, hemp seeds, in the apex of the lung. When the deposition in the apex has attained to that extent that the weight of the part is materially increased, and in a square inch there may be present some ten or more tubercles, giving a solid feeling to the lung, and when the inflation of the vesicles is prevented to a considerable extent both by tubercle and excess of liquids in the vessels and intercellular tissue, then the antero-posterior diameter is reduced. This reduction we discover by employing callipers, one extremity of which is placed upon the scapula, and the other upon the front of the chest, under the clavicle. The reduction in the antero-posterior diameter of the thorax at its apex, thus measured, frequently amounts to half an inch in the first stage of phthisis.

The semi-circumference of the chest in the first stage of phthisis at the base is also sometimes abnormally affected. It is occasionally enlarged when, pleuritis having supervened, effusion takes place to a considerable extent. But this accident in the first stage is rare, not occurring perhaps above once in 100 cases. Phthisis supervening upon effusion within the pleura is not here included, for we speak only of effusion supervening upon phthisis. When effusion supervenes in the first stage of phthisis, the increase to the semi-circumference of the chest may amount to one inch, to one inch and a half, or even two inches. This increase generally continues only a few weeks at most, and is invariably followed, if the patient survive, by a return to the normal dimensions, lasting only a few days, and giving place to an abnormal reduction, gradually increasing for some weeks, until the reduction amounts to one, one and a half, or two inches. A material reduction, unpreceded by an increase, occasionally takes place in the first stage. In a small proportion of cases, pneumonia occurs, and after some weeks, retraction of the side follows, and the semi-circumference of the diseased side may be one or two inches less than that of the opposite side. The reduction of the semi-circumference of the diseased side in the first stage of phthisis occurs perhaps not more frequently than once in ten cases presenting themselves at the hospital. It seldom occurs at the very earliest period of the first stage, but chiefly in the latter period, when the patient's health is materially affected; his breath much quickened and shortened, and when the percussion sound is much more dull than natural, and when great deficiency of respiration is detected by the differential stethoscope employed bi-laterally. It is in the second and third stages of phthisis, as we shall soon find, that reduction of the semi-circumference of the thorax chiefly takes place. It is an abnormal condition more of these stages than of the first.

In not a few examples of undoubted phthisis in the first stage, I have ascertained that an increase of the semi-diameter of the diseased side had taken place when no effusion was present. I have found the increase to amount to half an inch on the left side, and to half an inch and to one inch on the right side. The increase has depended upon the presence of tubercle and a hypertrophied state of the lung, the result of over nutrition, and upon a highly and widely diffused congestion of the pulmonary structure. The presence of vocal fremitus and of respiratory sounds, close to the ribs, have served to exclude the idea of the increase being dependent upon effusion within the pleura. That the body and base of the lung in the first stage of phthisis do really become enlarged, I have ascertained, by observations made in the dead-house.

The deviations in the semi-circumference of the thorax are best discovered and measured by the employment of the tape measure.

CHAP. XV.

FIRST STAGE—*continued.*

Vital Capacity of the Lungs.—Deficiency.—Little Value of this Test.—Modes of ascertaining vital Capacity.—Hutchinson's Spirometer employed at the Hospital.—Hutchinson's Table.—Variations of vital Capacity in Persons of same Stature.—Instrument valuable chiefly as a negative Test.—Resistance of Chest to Pressure.

AT an early period of phthisis, the amount of air which can be drawn into the lungs by a forced inspiration, and the amount that can be forced from the chest by a full expiration, is materially reduced. This diminution proceeds with the progress of the deposition of tubercle, and even with the expectoration of it, and the formation of cavities. The cavities which form in a solidified mass, though they admit air, do not coincide with an additional general air capacity, for they seldom admit much, in consequence of costal pressure, and of the operation of contracting fibrous exudation, and their formation is for the most part co-ordinate with the further deposition of tubercle in other parts of the lungs, and the hepatization of intercurrent pneumonia.

As soon as tubercle has filled up a considerable number of vesicles, it is clear that the amount of air that may be inspired must be reduced, and this reduction of vital capacity, as with some impropriety it is styled, may be detected, if a careful experiment be made, ere percussion has become sensibly affected, or ere the respiratory sounds have become harsh or locally deficient.

The fact is obvious that the so-called vitality capacity must be reduced at a very early stage of phthisis; but as we have no means of ascertaining to a nicety, or even to a close approximation, the precise amount of capacity that is normal for the individual, we are at fault when we desire to know whether a certain not materially deficient capacity be unhealthy. The capacity varies in health to a considerable extent. The general range of capacity that is normal includes many degrees of deficient capacity in individuals, depending upon disease. Indeed, the normal range descends as low as the abnormal range of capacity in a considerable proportion of examples of phthisis, in the early part of the first stage, even when the respiratory sounds are assuming the phthisical characteristics. One male of 5ft. 8in. in height, will expire 220 cubic inches, while another of the same stature will expire only 180 cubic inches; while I have ascertained that some persons of the same stature, in the early part of the first stage of phthisis, with altered percussion sound, and the phthisical respiration sounds, will expire not less. Taken alone, reduced vital capacity, if moderate, is of little value as a diagnostic sign of disease generally. It is of still less value as a sign of phthisis in particular. But if associated with altered percussion, harsh and deficient respiration confined to one apex, it is a somewhat valuable element in the body of evidence. It serves as a fair corroboration of the other physical signs. Deficiency of vital capacity is common to many other diseases. It is observed in bronchitis, in emphysema, in hepatization, in asthma, in cancer, in empyema, and in many diseases of the heart.

To be of any value as evidence of phthisis, the reduced capacity must be constant. If occasional only, it does not depend upon disorganisation. Deficiency of vital capacity, besides being common to many diseases, and being frequent as a natural condition, and dependent upon many physical and even moral influences of a strictly temporary character, possesses this disadvantage as a diagnostic sign of phthisis, that it points to no part of the pulmonary structure, to the apex or the base, or to the right lung or to the left, as the seat of tubercle, and therefore in these respects it comes in point of value much behind the signs of percussion and respiration, which not only denote tubercle, but indicate with exactitude, its precise situation.

The amount of expired air may be readily measured by breathing through a tube into a jar filled with water, and inverted over water in a reservoir, and so graduated as to denote the quantity of air which is received. But the measurement of the expired air is best effected by means of the spirometer of Dr. Hutchinson, and that of Mr. Coxeter. Dr. Hutchinson's instrument has been employed by myself in making the observations which are here recorded. An account of this instrument will be found at a subsequent part of this work. It is in constant use at the Hospital for Consumption. Every patient on admission, who is able to undergo the unavoidable fatigue, is made to use this instrument, and his vital capacity, as it is called, is ascertained and carefully recorded. However, it is but right to say that very little weight is attached by any of my colleagues, as far as I know, or by myself, to this test, and that we regard it in diagnosis as of infinitely less importance than percussion and auscultation, either singly or together.

When tubercle is very fully deposited in the lung, the vital capacity is notably diminished. Dr. Hutchinson has formed the following valuable tabular estimate of the vital capacity in the first stage of phthisis; but I am of opinion that the patients whom he examined were in an advanced part of the first stage, and that in some of them the disease was present in both lungs, and invading more than the upper lobes. Without the very slightest idea of impugning the diagnostic skill of Dr. Hutchinson, to whom we all are much indebted, knowing from much experience that some cavity signs are frequently absent for a time, I am strongly of opinion that a few at least of the cases regarded by him as having been only in the first, were in reality in the third stage of the disease. I have myself, on the first examination of many patients, found abnormal signs belonging to the first stage only, and on a subsequent examination a few days after, I have heard the conclusive cavernous respiration and the conclusive cavernous gurgling sounds.

For the purpose of more easy comparison with the healthy standard, as given by Dr. Hutchinson, I have placed the vital capacity of the first stage of phthisis, as given by the same authority, in juxtaposition with the natural or healthy estimate:

Height.					Capacity in the 1st Stage of Phthisis.	Capacity in Health.
Feet.	Inches.		Feet.	Inches.	Cubic Inches.	Cubic Inches.
5	0	to	5	1	117	174
5	1	,,	5	2	122	182
5	2	,,	5	3	127	190
5	3	,,	5	4	133	198
5	4	,,	5	5	138	206
5	5	,,	5	6	143	214
5	6	,,	5	7	149	222
5	7	,,	5	8	154	230
5	8	,,	5	9	159	238
5	9	,,	5	10	165	246
5	10	,,	5	11	170	254
5	11	,,	6	0	176	262

I have found that some few persons of very different stature have expired the same amount of air, even when none of the results could possibly be referred to nervousness or to inacquaintance with the operation of the instrument. Thus two medical men, well accustomed to the use of the spirometer, have breathed out the same amount of air, though their stature was respectively 5 ft. 4½ in., and 5 ft. 8½ in. The amount expired was in each case 220 cubic inches.

The evidence of the spirometer, judged of simply by the above table, is only a very rough test of phthisis. If employed in the early period of the first stage, the instrument would doubtless detect a diminution, though a small one, of the vital capacity.

It may be observed, in respect of this test, that as far as phthisis in its first stage is concerned, diminution of capacity by itself is of little value, but that excess on the normal amount, as established by Dr. Hutchinson, is of great negative diagnostic value, for under these circumstances we never find phthisis, and seldom any other disease of the lungs, or indeed of the respiratory organs. This negative value is very satisfactory in that not very small class or group of cases in which we have gradual wasting of the body with hectic symptoms, marked with shortness of breath and some little cough, which presents itself to the physician, and in which no phthisical physical signs are made out. If we find the vital capacity to be natural, or nearly so, we may conclude that the disease is not phthisis.

The resistance to the pressure of the fingers, offered by the thorax, is, in some cases of phthisis in its first stage, sensibly increased; but this is never perceived until the auscultatory and percussion signs are unequivocally developed. This increased resistance is much more a sign of phthisis in the third than in the first stage of the disease.

CHAP. XVI.

FIRST STAGE—*continued.*— ASCULTATION *resumed.*

Thoracic arterial Murmurs.—Influence of the respiratory Acts.—Influence of Force of cardiac Contraction.—Occasional Absence.—Little Value of this Sign.—Causes of it.—Loudness of cardiac Sounds.—Value of it.—Mechanism.—Comparative Power of solid and aeriform Bodies to acquire Sound from solid Bodies.—Adventitious Heart Sounds.—Venous Humming.

A PHYSICAL sign, remarkable in its character and readily audible, occasionally attends the first stage of phthisis. It consists of a gentle blowing arterial murmur at the apex of the chest. It may proceed from the pulmonary artery, the left subclavian artery, or the innominata on the right side. It seems to arise from the consolidated tuberculated lung pressing upon these vessels. The murmur or blowing is always systolic. The pulmonary artery, in my experience, has been the most frequent seat of this sound; the left subclavian, and the innominata give out this sound considerably less often, and they (the two last-named vessels) are the source of it in nearly equal frequency. When the pulmonary artery gives out this sound, it is heard over a small nearly circular area of about one and a half and two inches in diameter, of which a point about half an inch from the sternum, and in the middle of the second costal interspace, is the centre. Beyond this range the pulmonary artery murmur, so originating, is very seldom heard. On a few occasions it has extended an inch beyond this area, in an oblique direction upwards and outwards towards the outer extremity of the clavicle. It is never heard at the apex of the heart, or in the *direction* of the apex of the heart. The murmur when proceeding from the left subclavian is higher, and is heard loudest at the first costal interspace near the sternum; it seldom or never reaches to the neck. When the innominata is the seat of the blowing murmur, it is heard on the right side of the sternum at the first costal interspace, and may be traced up to the clavicle in an oblique direction, passing outwards and upwards. It is rarely heard above the clavicle. The intensity of the sound is not uniform; it varies with the force of the heart, as do most other arterial murmurs; but the variation that is most remarkable is that which holds with the different acts of respiration. It is rare to hear a murmur arising from the pressure of tuberculated lung, that is not affected in its intensity by some one condition of the respiratory function. The condition that intensifies may be inspiration, a very full inspiration, a very full inspiration with the breath then held, or it may be the act of expiration. In the first stage of phthisis, I have found that the inspiratory act is generally attended with a slight increase of sound. But the greatest intensification, and it is really remarkable, is obtained when after a full inspiration the breath is held. It would appear that the conditions for the generation of the sound are now at their maximum. The tuberculated lung is, as far as possible, filled out and made to press upon the artery, while the heart beats with unwonted force, and propels the blood with energy through or into the compressed vessels, enlarging them beyond their normal size. In some examples of this arterial whiff or murmur, I have heard the sound only during the act of expiration; but this has been less common in the first than in the third stage.

This sign is made out in about five per cent. of cases of phthisis in the first stage. The arterial systolic bruit of the first stage of phthisis is seldom perfectly uniform, even when it is continuous. It rises and falls in intensity with the force of the heart's action. When the heart is excited the sound becomes heightened, and when the cardiac contraction is reduced in force, the bruit is lowered. At least this variation is found in most examples. In not a few persons in whom this physical sign is heard, it disappears, or altogether fails to be heard, for a time. Thus after having been heard very distinctly, the utmost attention will fail to detect it a few hours after. I have sometimes been disappointed with this silence, for it caused me some doubt as to the accuracy of my first examination. But I soon learned that the silence of one day did by no means argue the absence of sound on a previous occasion. The silence or the absence of the arterial bruit, after it had been distinctly heard, has been due to reduced force of the cardiac contraction. The sound has been got rid of by quietude, and it has generally been reproduced by sharp walking in a room. This non-persistence is valuable in diagnosticating this sign, the result of phthisis from that occurring in arterial obstruction. The disappearance is more common in phthisis than in valvular disease. Taken by itself this arterial sign is of no diagnostic value in the first stage of phthisis; and associated with other signs that are conclusive, it is confirmatory, but it is also almost always superfluous in the diagnosis. It is just possible that in some very rare examples a marked arterial systolic bruit proceeding from the arteries may be present from the pressure of tubercle in the lung, immediately and exclusively in the vicinity of the arteries when the percussion note may be little affected; but such a coincidence must be rare, and it would be unsafe to rely much upon it. Occurring by itself, then, an arterial whiff is by no means conclusive of the presence of tubercle; it may be held to justify some suspicion, and to suggest further watching and renewed exploration. If associated with loss of weight and obscure hectic symptoms, the explorations should be more frequently repeated and the more rigidly performed. The mechanism of the arterial bruit is this. The tubercle presses upon the artery, causes the walls to come in more than usual collision with the moving column of blood, and more than the usual sound is produced. Besides this, another cause is in operation in most examples: the heart's contraction is preternaturally excited, and the column of blood is thrown with more than the usual violence along the arterial channel. The obstruction in the channel is reinforced by the additional force of the current, and thus another element in the production of sound is added.

The loudness of the sounds of the heart is another early sign in phthisis. In a large proportion of cases of this disease, even in the first stage, the stethoscope placed under the clavicles seems to convey to the ear the sounds of the heart in an exaggerated manner, or in a louder tone than is natural. The impression made upon the ear serves to convey the idea that the heart is preternaturally near, and that the action of that organ is unduly excited. At all stages of the respiratory act this increased intensity is observed.

The value of this sign is not great. Unless supported by tubular breathing, dry crackle, very long expiration, shortness or dullness of the percussion sound, it would be extremely dangerous to rely much upon it as evidence of phthisis in the first stage. One or more of these signs are essential to give it any positive value as a sign of phthisis. All of the signs referred to are not necessary; but one or more are for this purpose. When cardiac loudness is found alone, and when the action of the heart is not greatly excited, and when the body of the patient is slowly wasting, and when cough, though very moderate, and some continuous shortness of breath are present, preternatural intensity of the heart sounds, though not conclusive of the presence of incipient phthisis, is not to be held worthless, but justifies the suspicion that this disease is present.

In the case of nervous patients with rapid pulse this sign is still less reliable. But the presence of it in nervous patients is not to be altogether disregarded; for nervousness and phthisis may, and often do, co-exist. To give it value in such patients the presence of the other confirmatory signs above noted is the more necessary. This sign acquires a degree of value when it is confined to the right side.

The mechanism of the increased intensity of the heart's sounds in the first stage of phthisis appears to be this: the greater density of the lung increases the property of receiving sound from solid bodies, such as the heart; and a solid body in sonorous modulation, such as the lung, moderately tuberculated, is better calculated to convey its sonorous undulations than an aeriform body, or a comparatively aeriform body, such as the fully vesicular lung, to another solid body, such as the walls of the chest. It is doubtless true that solid bodies bestow their sounds freely upon aeriform bodies, but it is also true that by the looseness of the particles of such bodies, and by the diffusion in all directions of air, under ordinary circumstances, sound is soon dispersed and sensorially lost. When air is confined in a tube after receiving sound from a solid body, the sound is maintained in very considerable intensity, and may be conveyed a great distance. In the acquisition by a solid body of sound from another solid body, an element in the production of the phenomenon is the weight with which it presses upon the body from which it borrows sound. The weight of the body offers a resistance to its displacement in the mass or lump, and exposes its particles to the molecular motion which is essential to sound, and, indeed, upon which sound depends. Wood *lightly* placed upon a sounding body, such as a musical box, accepts sound much less fully than wood that is applied with a moderate degree of pressure or force. It is true, however, that *much* weight, on the other hand, may prove unfavourable to the acceptance and conveyance of sound, for this weight may interfere with and impede the sonorous vibrations of the sound-communicating body; or, in other words, the force of the original sounding body may not be sufficient to throw into molecular motion the heavy superincumbent body. This may be proved by placing rods of wood of different densities upon a musical box. The very light wood conveys less sound than the more heavy; but if a heavy iron rod be employed, the sound that is communicated is again reduced, the weight of the iron impedes the movements of the musical box, and the iron is too heavy and resisting to be thrown into the full vibration of wood by the sounding instrument. We have much the same thing produced in auscultation of the chest: lung that is moderately dense, as from the presence of tubercle, conveys sound well; but if very hard and very dense, and the originating sound-body be feeble and easily restrained in its molecular motion, such as the flaccid heart, the sound is feebly conducted, and is sometimes inaudible. This will serve to explain the conflicting facts which have been observed in relation to sound and consolidated lung. Sometimes the sounds have been found feeble, and at other times they have been found to be increased in intensity. In all cases there has been consolidated lung; but in reference to the sounding body, it has been sometimes, from great density, opposed to acceptance and conduction, while it has been at other times favourable to acceptance and conduction, from lesser density and lesser resistance. Resistance to some extent is necessary for the acceptance of sound; but resistance beyond a certain amount and proportion may be fatal to this office. When the lung is moderately solidified by tubercle, it will come in contact with the heart with more force and weight than finely vesicular lung, and will therefore accept sound more from that organ, in the same manner as the heavier piece of wood laid upon a musical box accepts sound, as has just been mentioned. If very heavy, the lung may impede the vibrations of the weak heart, and may even itself fail to be fully thrown into corresponding sonorous vibrations; and thus a deadening or damping effect may be produced, as in fact is sometimes observed. We have seen that hollow wooden and glass rods vibrate better than solid ones. Consolidated lung, such as the tuberculated structure, once in vibration will convey or propagate its movements to the solid walls of the chest and the solid stethoscope placed upon it better than fine vesicular lung, for this reason, that solid bodies, as has been before stated, are more suitable for propagating sound to solid bodies than aeriform bodies are. When bodies are neither wholly solid nor aeriform they maintain this characteristic in proportion to their solid or aeriform constitution. Lung with a moderate amount of tubercle, therefore, accepts sound and propagates it to solid bodies, such as the walls of the chest, better than vesicular lung or emphysematous lung.

ADVENTITIOUS HEART SOUNDS.—In the first stage of phthisis certain diseased conditions of the heart and great vessels are wont to be developed, and though their signs cannot be regarded as the primary signs of pulmonary consumption, yet they are in a manner signs of that disease, for it is to that disease the secondary disorders which they denote are referrible. They are truly signs of pulmonary consumption, but they are secondary signs. With this qualification, these signs are well worthy of some notice in this place.

The to and fro friction sound of pericarditis is occasionally heard in the first stage of phthisis. It occurs, for the most part, not until the original malady has continued some weeks or months. It is found chiefly in those examples of disease conjoined with pneumonia and pleurisy. The rheumatic, and those suffering from disease of the kidney, seem to be the most frequent sufferers. It is extremely probable that it is not uncommon in those subjects who are sufferers from deposit of tubercle in the kidney, and these are not a very small number.

Basic arterial murmurs have been occasionally heard by me in the first stage of phthisis; and from much post mortem exploration, I believe them, in a considerable proportion of cases, to have been due to the spreading of inflammatory action from the lung to the great arterial ostia, or to vitiation of the blood by the pulmonary disease doing the same thing, or to the direct deposit of tubercle in small yet visible amounts in the coats of these vessels. The murmurs which I have attributed to phthisis in this stage have been always systolic. The aorta has been much more the seat of this phthisical murmur than the pulmonary artery. The murmur is always persistent, and much the same during every part of the respiratory act, which is not the case with murmur originating in mere tubercular pressure already noticed. This form of murmur is usually accompanied with excited and tumultuous action of the heart, always persistent to a greater or lesser degree.

A venous humming at the thorax has been heard by me in a few examples of phthisis in the first stage. It has been heard over the seats of the innominata and the subclavian veins. It has been heard chiefly during inspiration. Sometimes it has been conjoined with venous murmur in the neck, but sometimes it has been found alone. It has not been peculiar to females. It is the single humming in the thorax that I have regarded as chiefly due to the presence of tubercle. It has always been found on the tuberculated side. In some cases hæmoptysis had taken place. Moderate pressure from tubercle has appeared to me to be the chief cause. Anæmia has probably aided.

CHAP. XVII.

FIRST STAGE—*continued.*

General Character of thoracic Signs.—Signs of acute Phthisis.—Grouping of thoracic Signs in different Cases.—Duration of Signs.—Tendency to Progression.—Occasional Subsidence, naturally and under Treatment.—Noncessation of Signs at Conclusion of first Stage.

THE thoracic signs of the first stage of phthisis are tolerably persistent. They are gradual in their development, and they seldom appear for a considerable time except in the society of each other in the chronic, and much the most frequent form of the disease. The roughness of inspiration is liable to some variation in degree; the more hurried the respiration is, the more rough is the respiratory sound. The length of the expiratory sound varies considerably, but it seldom disappears for a time. The subsidence of bronchial congestion, or of tracheal or laryngeal obstruction, is frequently followed by a more healthy expiratory sound. The pectoral voice is usually persistent, and tends to increase as the deposition of tubercle proceeds, until it compresses the bronchi; but this is liable to reduction upon the voice becoming weak, either from general debility or from laryngeal diseases. The pectoral voice disappears altogether, not unfrequently when the voice assumes a whispering low character. The shortness of duration or dullness of the percussion sounds tends almost uniformly to increase with the age of the first stage; but I have occasionally noted a tendency to the resumption of the natural note, and this has occurred when there has been reason to believe that tubercle has been absorbed, or that plastic lymph, the result of inflammation, has been removed.

The thoracic signs of phthisis, in its acute and much less frequent form, present collectively some points of difference from those of chronic phthisis. The respiratory sounds are fuller; the sounds are more vesicular and less tubular; the extent of the signs is, quoad space, much more extended, and generally comprises both sides of the chest; there is more uniformity of the physical signs throughout the thorax. Sibilus and sonorous rhonchus are widely diffused, and the fine crepitation of pneumonia and capillary bronchitis are frequently present. The percussion sound is little altered considering the general disturbance, and is devoid of that very common locally restricted alteration which we so commonly and generally find in chronic bronchitis. On the whole, compared with the danger to the patient, and with the rapidity of respiration and the break-up of the health, the signs of acute phthisis are ill developed compared with those of the more common and slower form of the disease. The duration of the signs of the first stage of the acute form of phthisis is of course short, and these are soon replaced by, or associated with, the signs proper to the second stage. The first stage may not last longer than two or three weeks. But death frequently occurs during the first stage; while it is comparatively rare for the patient to die in the same stage of the slow form of phthisis.

The grouping or association of the thoracic signs of phthisis is found to be various, and it is well to know the more common facts relative to this point. In perhaps the largest group of cases in the first stage, presented at the hospital or at a physician's house, we have associated together a certain dullness on percussion, roughness and deficiency of inspiration sound, a slightly tubular bruit, long expiration, moderate flattening, and defective motion. In some cases the percussion is not sensibly altered, and the only auscultatory signs are harshness of inspiration sound, and increased duration and coarseness and loudness of expiration. In a group of cases, certainly advanced, the percussion sound is extremely dull, and the respiration is remarkable for great tubularity, the thoracic voice is very strong, and the motion is very defective. I have spoken of acute phthisis already; but I may repeat here the group of signs are generally these —scarcely altered percussion sound, scarcely altered motion, sibilus, harshness without deficiency of inspiration sounds, and rather fine crepitation.

The duration of the thoracic signs of phthisis varies much. In warm climates it is longer than in this country. It ranges from three months to some three, or even five, years. The more common period is from six months to one year. The signs of the first stage usually last much longer than those of the second, but in duration they are often exceeded by the third.

To progress and become better pronounced is the usual character of the signs of the first stage. But it is to be observed that in some comparatively few cases they tend to abate: thus, the percussion becomes more clear, and the rough harsh character of respiration sound somewhat abates, though the deficiency may remain. This happy course of things occurs chiefly when phthisis has arisen from the operation of cold, or of other active agencies which have now been removed or avoided. Treatment, too, in the case of good or fair constitutions, is successful in arresting the development or increase of signs, and even in reducing those that have been already induced.

The thoracic signs of the first stage of phthisis, we shall find, do not, as a whole, disappear on the accession of the second stage. The roughness or defect of inspiration sound, and the prolonged expiration sound, certainly disappear at the spot where tubercle is softening, and the lung is becoming cavernulous; but it very generally happens, while these sounds are disappearing in the original spot, and are being replaced by the signs proper to the second stage, they are manifesting themselves in other parts, either in the opposite lung, which had been hitherto healthy, or, when both apices are softening, in the base of one lung or of both. The dullness on percussion increases instead of disappearing on the accession of the second stage. Bronchial respiration may continue, but it is less obvious, and may be said to be replaced by the moist and cavernulous crepitations proper to the second stage. The force of the pectoral voice, and its ringing, metallic, vibratory shaking character is, I believe, for the most part, reduced, when the disease has entered fully into the second stage, viz. that of softening, and when the bronchial tubes and lung tissue are infiltrated. However, in many cases of phthisis, in the second stage, the greater intensity of the voice on the diseased is observed as it was in the first stage.

CHAP. XVIII.

FIRST STAGE—*continued.*

Physical Signs of the Throat. — The Voice. — Weakness of Voice. — Hoarse Voice sometimes a very early Sign. — Whispering Voice and Aphonia.—Hemming.—Auscultation of Larynx.—When these Signs suggest Phthisis.—Excessive Movement of Larynx and Trachea.—Cough an early Sign and why.—Characters.—Diagnosis of phthisical Cough.—Auscultation of constrictive laryngeal Sounds, &c.—Mouth and Nares.

THE voice of the patient in the first stage of pulmonary consumption is not unfrequently materially or sensibly altered. I have known a weak or hoarse voice to be one of the very first physical signs of the disease, and to have suggested just apprehensions before the thoracic signs had manifested themselves in a reliable degree. The alterations of the voice are, therefore, not without value in a diagnostic point of view. I have observed alteration of the voice in a very considerable proportion of examples of the disease in the first stage. At an early period of the first stage the proportion is small, perhaps not more than one in twenty cases. At the conclusion of the first stage it is higher, perhaps one in ten cases.

One of the first forms of alteration, as well as the more common, is a weakness of the voice. The tone and character of the voice are unaltered, but the voice is formed with less force and intensity. This weak voice loses its accustomed pitch, and assumes a monotonous even character. It is sometimes unequal: the force of the voice varies, being higher at one time than at another, and occasionally sinking extremely low, imitative of a whisper, it may be for a few minutes only; a "hemming" will occasionally restore the voice to nearly its natural pitch and force. The weakness or lowness of the voice may show itself only after some amount of talking. A fit of coughing occasionally restores the natural character of the voice. In some cases of phthisis the alteration is first noted in the singing voice: the patient fails to raise it to its ordinary pitch; but after a time acute and discordant notes are produced, the pitch being suddenly and greatly raised for an instant.

The voice in some cases, and these are not rare, assumes a hoarse or "thick" character, as if the vocal chords and the larynx generally failed to vibrate with that fullness and clearness that are natural. This condition is pretty uniform, seldom passing off altogether, yet still it is marked with inequalities; sometimes it is increased, and at other times, though very brief, it leaves nearly altogether. Sometimes this hoarseness will remain for a few days, and then leave the voice very nearly healthy. Upon exposure to cold air or to damp it is extremely liable to reappear.

I have known the voice not only to become whispering, but to be almost absent, for a few days, in the first stage of phthisis, constituting aphonia. When the general health is declining, occasional and evanescent aphonia should suggest the probability of tubercle in the pulmonary structure and in the mucous membrane of the air passages.

I am able to call to mind many cases of disease, at the commencement of which a hoarse voice was really the only physical sign that was discovered, and which have subsequently reached the third stage of phthisis under my own eye. There is now in the hospital a young man who, two years ago, came as an out-patient with the voice I have been describing. It was low, hoarse, and unpleasantly rough, and, as it were, dry. Suddenly, after a few words were articulated, it would break, and the succeeding word or two would be uttered at a high pitch, shrill and disagreeable. For months no chest physical signs of phthisis could be found that were conclusive of the presence of that disease. After some months a little moist crepitation was discovered on one side, and the patient has now very extensive moist crepitation and small gurgling. In this case numerous examinations were made; phthisis was early suspected, from the general debility and from the loss of flesh, as well as from the disease prevailing in the patient's family; yet the only result of several cautious explorations was such as has been described.

A "hemming" expiratory effort is frequently made in the first stage of phthisis, and is worthy of attention. After speaking a short time, the patient makes a strong and prolonged expiration, and at the same time he contracts the muscles of the glottis. A forcible current of air is produced, and this sweeps the edges of the glottis and the adjoining parts, dislodging mucus. With this effort a coarse aspirate sound is produced, which is called "hemming" or "hawking."

The tonsils and the pharynx may be swept by the same or nearly the same effort, and the sound then is coarser, and is heard to proceed not only from the glottis but from the fauces. After "hemming" it frequently happens that the voice becomes much improved. Sometimes a little glutinous, yellow mucus is discharged by this effort; sometimes a clear starchy jelly streaked with black pigment is brought up. A little frothy, whitish foam is often the only material discharged. After the first effort, nothing whatever in the shape of sputum is produced. I have occasionally seen florid, frothy blood discharged by the "hemming" of phthisis in the first stage, particularly when the effort has been violent and frequently repeated.

When the stethoscope is laid upon the larnyx or trachea in the first stage of phthisis, it will be found in a very considerable proportion of cases that the sound of the entering column of air is heightened or increased in intensity. The inspiratory sound, too, frequently acquires a marked roughness. Sometimes an abnormal blowing character is added, as if the entering column proceeded faster than natural. Occasionally a constrictive sound is heard, and this evidently proceeds from a thickened and congested condition of the mucous membrane invading and contracting the calibre of the tube, and causing a loss of proportion between the quantity of air required in the lungs and the channel for conveying it, the last being abnormally reduced. Occasionally, with or without these alterations of the tracheal and laryngeal respiratory sounds, a large mucous rhonchus or râle is heard from the passing air breaking down a film band or membrane of mucus. When the mucus is thin, bubbling or clicking is heard. These sounds may be formed in the larynx or trachea, but they may proceed up from the bifurcation of the trachea, or even from a lower point.

For the examination and discovery of the sounds of the larynx and trachea, Dr. Camman's stethoscope or my own differential instrument should be employed. The lightness with which they may be applied to these delicate and compressible parts, render them very superior to the wooden stethoscope, which is indeed almost inapplicable, on account of the unavoidable pressure upon the patient which it entails.

When with failing health and the absence of local signs of disease in the fauces, these tracheal and laryngeal sounds are heard, they must be held suggestive of phthisis. When, on the other hand, the fauces have been long congested, when there is ulceration, or when there are signs of recent acute inflammation, when the urgent symptoms of laryngitis and croup are pressing, it is little likely that phthisis is present.

The motion of the larynx and trachea is sometimes observed to be affected early in phthisis. These parts, instead of being stationary during respiration, are seen to move more or less. During inspiration they descend, and during expiration they ascend. This motion takes place in a degree corresponding with the shortness of breath or with dyspnœa. It is generally moderate, but it is increased upon exertion, or after eating, or any event that quickens the circulation of the blood. The trachea seems to dip into the thorax during inspiration, and to rise out of it during expiration. In dyspnœa, from asthma, and other diseases, these abnormal motions are much greater. In phthisis it is pretty uniform, and is almost always very moderate. It steadily increases with the progress of the disease.

The percussion of the larynx and trachea in the first stage of phthisis elicits no abnormal signs.

The vocal fremitus is unaltered. Hoarseness increases it.

Cough.—It may be a question whether cough should be here treated as a physical sign, but to me it appears that it is strictly proper to class it along with the signs which are now being described, for it certainly is a physical sign, and appertains more to the throat than to the chest. The series of involuntary, and more or less violent expirations which constitute it, give rise to sounds which are very sensible both to the patient and the physician. They early occur in the first stage of phthisis, and are not unfrequently the very first sign or disturbance which awakens the suspicion of consumption, not only on the part of the patient, but subsequently on that of the medical attendant. This sign has characteristics which will often prove to be of some value in distinguishing phthisis. When the respiratory characters of early phthisis are ill developed, and when they are still unsupported, and uncorroborated by the absolute or comparative percussion signs of this disease, the examination of the cough as heard through the atmosphere, or through the larynx and trachea and the chest, by means of the stethoscope, will greatly aid in diagnosis.

Cough varies much in its characters. In other words, there are many varieties of cough. Some are of little import, and belong to maladies and disorders of very little gravity, while others denote very important diseases, such as that treated of in this work. To the untutored ear the differences in the characters of cough are of little weight. The differences are little regarded, and they signify little or nothing; but to the auscultator's ear, a cough is more than a mere cough as the world estimates it, and it possesses qualities, which with very considerable certainty, associate with it, in the mind of the skilful physician, diseases of very different characters and of very different importance, in reference to life and the danger to, or the comparative safety, of it.

We have spoken of a certain roughness of respiration, a deficiency of the inspiratory sound, of prolonged noisy expiration, of abnormal differences in the quality of sounds in different parts of the chest, as ascertained with great precision with the aid of the differential stethoscope, as being the first signs of the deposition of tubercle in the lungs, but unless we are to regard these signs as more particularly signs than cough is, we do wrong, for certainly we have heard the phthisical cough in phthisis some time before we have become satisfied of the presence of the ordinary physical signs already described.

It is easy to conceive that this physical sign should be developed at a period when tubercle is being deposited in the minutest particles. The morbid excited action which almost always attends, and that indeed is one part of the series of causes of the deposition, is very likely, all must admit, to produce that nervous irritation which excites coughing. We know how very little vascular over-action, and how small an amount of extraneous material in the air passages and air cells of the lungs will suffice to induce this convulsive or spasmodic act and its attendant noise. How reasonable to suppose that long before tubercle has attained to that mass and proportion necessary to produce an appreciable shortness or dullness of the percussion sound, sufficient irritation may be present to induce the act of coughing. Even the deficiency and the roughness of inspiration which attend tubercle when deposited in small quantities, may be associated at the very first with that impression upon the nerves which will suffice to produce tussive phenomena; and it is not at all unlikely, in my opinion, that cough may even precede any respiratory sign upon which we can rely. If this be correct, the study of the cough of phthisis is of great importance, for it may enable us to detect the presence of this fell disease at an earlier period than we can do with any other sign. If the cough precedes other and reliable signs, and if the phthisical cough can be diagnosticated, then we shall have the very great advantage of earlier intelligence than we have hitherto obtained.

Whether the cough of phthisis possesses features different from the cough of other affections, and whether by its history it can be diagnosticated, it is now our duty to inquire. I believe its history — by which I mean its mode of origin, the circumstances under which it arises, its behaviour with the lapse of time, and the sounds which mark it, will be sufficient to specialise it and to enable the careful observer to recognise it, so that it shall prove a useful and a tolerably reliable sign, if not a conclusive one. Though not conclusive of the presence of tubercle, it may be held, I doubt not, of nearly equal value, viz., conclusive of the extreme probability of this deposit. It will early supply us with that reasonable amount of proof that will justify us in making any effort to arrest a nascent disease, and to warrant the patient in making sacrifices towards this end. If more convincing evidence be wanting, if a little more proof would be yet desirable, this is counterbalanced by the fact that our early action tends in a very important manner to save human life; and after all, this, and not merely absolute certainty in diagnosis, is the great end of medical art, and should be the constant aim of every physician.

The cough of the first stage of phthisis is, as writers have all along described it, a short one. It is not preceded by a specially long inspiration like the cough of whooping-cough. The respiration immediately before is not different from that observed in the intervals. Suddenly a short, harsh, quick involuntary expiration is made, producing a rough and somewhat but not very constrictive sound at the glottis; this is succeeded by a short almost imperceptible inspiration, marked by a very slight glottis-inhaling sound. Another forcible, quick and involuntary expiration follows instantly, the interval between the first and second expiration not generally exceeding more than one moment or half a moment: this is succeeded by an almost imperceptible imperfect inspiration. These acts of quick and forcible expirations and inspirations occur till some three, four, or five or six are accomplished, the duration and relative periods above indicated being strictly observed, the last inspiration is generally long and somewhat noisy. At first the series of acts do not generally exceed three or four, and as the sound which accompanies them is not very loud, and as the tussive act does not much distress the chest, or produce deep respiration, such as follows violent coughing, this sign is frequently little attended to, either by the friends and attendants, or by the patient himself. So little is the impression made by this kind of cough, that the physician is frequently informed that it does not exist, when it has really for some time been experienced. The patient himself will frequently maintain, in opposition to the testimony of his friends, that he has no such symptom, and evinces a remarkable solicitude and repugnance in respect to being thought to suffer from it. This cough occurs during the whole waking day, at intervals more or less prolonged. A series of such convulsive or spasmodic acts may occur every half hour or every hour, or it may be that an interval of some three or four hours is observed between any two of them. Sometimes many series of these acts will occur in one hour, while several succeeding hours may pass without the occurrence of one of them.

Early morning when the patient awakes and when he rises out of bed, is generally marked by some of these acts of coughing. After speaking, after muscular exertion, frequently during eating and after it, during walking, after running, or while ascending stairs or an elevation, the patient is troubled with one or more of these spasmodic acts. Cough is common on lying down in bed; but in general sleep, at least at first, is little disturbed by it.

In the morning some sputum is generally expectorated: it is sometimes simply frothy, or, with this frothy sputum, generally white, a very small mass of light yellow or faint green material, of jelly-like consistence, streaked with black pigment, may be conjoined. There may be no yellow or green material, and but a small irregular mass of clear or semi-transparent, colourless, jelly or starch-like mucus may present itself, and this seems to be composed of several little masses joined together, loosely attached, and easily broken asunder with the finger: this usually contains a few dark streaks of pigment, like minute black threads or fibres in irregular lines. During the day the cough is usually dry, or the sputum is only whitish froth.

When the series of spasmodic acts is passed, the respiration is a little quickened for a few moments, and the inspirations are deepened. The deep inspiration which follows coughing in early phthisis is favourable to the auscultator's judging of the character of the act, as it takes place in the lungs. An inequality in the amount of the inspiration on the two sides of the chest is now readily made out, by means especially of the differential stethoscope; dry crackle, clicks, and tearing or rolling bruits are now exaggerated; and more readily made known to the ear. Sounds are not only exaggerated; there is reason to believe that air cells being now very fully inflated, sounds may be produced which otherwise would not be at all heard.

The cough of early phthisis is frequently attended by flushing, &c., of the face, but this is extremely slight compared with that observed during the violent cough of bronchitis, emphysema, pneumonia, and asthma, or of the third stage.

The heart's action is quickened for a few minutes; but this excitement, like the distress of the body, is generally slight compared with the results of coughing in many other diseases. The cough of crude tubercle in the lung is free from the very constrictive sound which accompanies croup, from the deep whoop and violent paroxysms of whooping-cough, and from the dry, constrictive, tracheal and large tubular sounds which characterise the cough dependent upon hysterical disorders. Neither is it marked, except in extremely rare cases, with the constrictive sound and great fremitus of the chief bronchi, which we have in some persons of nervous and hysterical constitutions. The absence of signs of inflammation of the fauces and tonsils; the symptoms of croup and laryngeal disease, marked by great, constant, and persistent alterations of the voice; the secretions of bronchitis; the pain of pleuritis, with its dull percussion; the febrile condition of pneumonia, with its flushed face, dyspnœa, and characteristic sputum, and the evidences of hysterical disorder, will serve to narrow the question and to exclude these various diseases.

The cough of phthisis begins without obvious cause, and is without the accompaniment of much physical suffering in the throat and chest, and is associated with only a moderate amount of shortness of breath, slowly increasing, and with a moderate progressive decline in strength and flesh. The cough, in a large proportion of cases, is soon accompanied with hæmoptysis; it may be only streaky, or it may be copious and flowing. The severity of the cough increases with time, and it resists treatment more than most other forms of this spasmodic act.

A sense of tickling and irritation at the glottis often precedes the cough, and seems to provoke it. When the act of coughing is over, the sense of local irritation is allayed for a time; and in this way, and by cleaning the larynx of mucus, the cough sometimes affords a little relief to the patient. The exhibition of opiates frequently abates the cough, but only for a time; and the general health generally loses more by the constant employment of such means, than the patient gains in respect of the cough, at least in the first stage of the disease, and it is only of this that we now treat.

Listened to by means of the stethoscope placed upon the chest, or upon the trachea, the cough is heard generally alone. A constrictive blowing only is superadded, or a sibilus may be heard. The sounds are somewhat distant, passing through the lung substance. The crepitations, gurglings, and cavernous blowings of advanced phthisis, the fine crepitations of pneumonia, and liquid crepitations of œdema, are absent in the thoracic sound of the cough of phthisis in the first stage.

The tussive bruits of the first stage of phthisis are distant, and permeate a dense lung, while the tussive sounds of the third stage are generally superficial, and reach directly into the ear, as it were.

The passage of the respiration air into and out of the larynx and trachea is occasionally performed with difficulty in the first stage of phthisis. This arises from the presence of congestion or chronic inflammatory action in the mucous membrane of these parts. Sometimes the affection of the membrane involves ulceration; but this occurs much less frequently now than at later stages of the malady. When the congestion is considerable, and when thickening of the membrane takes place, particularly at the larynx, a constrictive blowing sound, more or less harsh and loud, takes place, particularly with the inspiratory act, the expiration is noisy and prolonged. The constrictive blowing is well heard by applying a flexible stethoscope to the larynx or trachea. The lengthened respiratory sound is also well perceived in the same way. But these morbid sounds travel down to the thorax, and may be heard there. The blowing sound serves to hide or mask rough or harsh respiration sounds of the lungs themselves. They are also liable to be erroneously taken for sounds originating in the lung when that structure is healthy. The lengthened expiratory noise of the larynx and trachea may be erroneously regarded as belonging to, and originating in, the lung, for it may be heard there. On the other hand, the long expiration due to disease of the lungs may be masked by it.

The prolonged expiration through the larynx, &c., also actually prolongs the expiration of the lungs when healthy, and consequently the sound which accompanies it. The diagnosis may be generally successfully made by attending to the seat of the greater intensity of the sounds, and to the voice. If they are louder at the larynx, they are of laryngeal origin, and the voice is usually and persistently affected.

The pharynx in the first stage of phthisis occasionally becomes the seat of physical alteration. The mucous membrane is roughened as well as reddened. The follicles become enlarged, and sometimes, but rarely, the seat of minute ulceration. I have occasionally seen thick, green, and yellow mucus attached firmly to the posterior wall. The morbid state of the pharyngeal membrane gives rise to frequent expulsive efforts, which produce a sound like the word hāāwk. The effort is usually styled "hawking."

The uvula is very frequently found to be unhealthy in the first stage of phthisis. It is unduly reddened, and venous ramifications are readily seen upon its surface. The whole organ is occasionally hypertrophied to a moderate extent. Sometimes it is very clubbed at its free extremity. Occasionally the mucous membrane at the extremity seems to fit loosely, and to be œdematous. Lengthening of the part is a common condition, and serves to bring the extremity into unpleasant contact with the rima glottidis and the floor of the pharynx; this causes much distress, frequent coughing, and almost continuous tickling in the upper part of the throat.

The gums, in a small proportion of cases, present a fine rosaceous line along the border which unites them with the teeth.

The nares, in a few cases, are the seat of irritation and some swelling, giving rise to a nasal twang more or less persistent, or recurring from time to time. The secretion is occasionally morbidly increased.

The morbid conditions above referred to seldom attain to very great proportions in the first stage; but as they often become serious, and demand treatment in the latter stages of the disease, they will be treated of again at subsequent parts of this work.

The mode of examining the mouth, &c., will be explained in the second part of this book.

CHAP. XIX.

SECOND STAGE.

General Remarks. — Moist Crepitation. — Great Value of this Sign. — Air or flexible Stethoscopes.—Progress in respect of Regions.—Limited Amount at first.—Great deficiency of respiration Sounds, and differential Stethoscope. — Size of crepitation Bubbles. — Squashing. — Mechanism: Film Rupture: Bubble Rupture. — Sound modified by Consistence of Liquid. — Crepitation affected by cardiac Movements.—Diagnosis of phthisical Crepitation.

The physical signs of phthisis in the second stage, the period of the softening of tubercle and of the breaking down of the surrounding pulmonary structure, are much more marked than those of the first stage, except at the very last part of it, viz., that which immediately precedes the accession of the second stage. They are also to be more depended upon, and are less likely to permit of errors in diagnosis. This is as we might expect from the consideration of analogous conditions. An evil long or some time established, or that has somewhat grown, is more likely to be discovered, readily recognised, and to be distinguished from other conditions than when it has only begun, when it is at its earliest origin, and before its characteristics have become well pronounced. In the second stage we mark three important circumstances connected with those portions of the lung originally diseased. The first is the absence of certain signs observed in the first stage; the second, the exaggeration and obvious increase of signs which are observed in the first stage; and the third, viz., the addition of new signs to those discovered in the preceding stage of the disease. Besides this, we discover signs of phthisis in portions of the lung which had been healthy, while the parts originally attacked with the disease were only in the first stage, but which have now become implicated. The signs discovered in the recently attacked parts are those of the first stage; but as a general rule these signs are sooner replaced by those of the second stage, than has held in the case of the parts originally infected. As a general rule, moist sounds very soon appear in parts after the deposition of tubercle, when softening has already occurred in another portion of the lung. From what has been stated, it therefore appears that when the disease has arrived at its second stage in one portion of the chest, the signs of the first stage are frequently exclusively found in others. It is very common to find the signs of the second stage in one apex, while those of the first stage only are made out in the opposite one. In this case, the lung in the first stage may have become diseased only after the lung presenting the signs of the second stage had arrived at this epoch; or it may be that the disease has progressed faster in one lung than in the other, and has attained to the second stage, while the opposite lung lingers on in the first stage only. The more common course is this, as far as observation permits us to say,—disease had progressed a great way in the more advanced lung, before the lung now affected with incipient disease had departed from its healthy condition.

The middle and the base of the lungs are also frequently the seat of the disease in its first stage only, when the apex or apices are decidedly in the second, and imparting the true signs of that period. In fact, we seldom find the signs of softening in the apex without discovering some at least of the signs of the first stage in the middle and the base of the lung. Sometimes the signs of the second stage are found simultaneously in the apex, the middle, and the base. It is more common to have these signs shared in common with the apex and middle only, than to have all three parts imparting the same signs. I have scarcely ever seen a case in which I have been able to satisfy myself that the second stage signs were present in the middle and in the base of the lung, while the signs of the first stage only were to be made out in the apex. That such cases do occur I have no doubt, but they are extremely rare. I have met in private practice, with a case of phthisis, in which I have made out a cavity in the base, while I have been able to discover the first stage signs only at the apex. In this case the second stage signs must have preceded the formation of a cavity. Similar cases, no doubt, occasionally occur, but they are extremely rare. When I come to speak of the morbid anatomy, this point will be further considered; but I may here state in the mean time that during the five years I have attended the autopsies of the Hospital for Consumption, I do not remember to have seen any lung excavated at the middle or the base, which had not progressed further than the first stage of the disease at the apex. It is by no means rare to find in the first stage of phthisis, as established by the presence of crude tubercle in the apex of one lung or of both, that there is present in the base of one side or of both, a certain amount of liquid, large crepitation, and of bronchophony, but this is much more frequently due to mere and my own differential stethoscope, has been even more satisfactory, full, and striking. I presume that this result depends upon the acoustic principle, that air sounds are best conveyed through air. It may be objected to this view, that between the air sounds, where they are formed in the lungs and the air instrument, viz., the air stethoscope, there is interposed a solid body, viz., the thoracic walls, consisting of intercostal soft parts and of ribs or cartilages, and that, therefore, when the sounds have arrived at the exterior of the chest they are really the sounds of solid bodies. But, in reply, I might suggest, that these solids only *tend* to destroy the air character of the sounds, and do not absolutely succeed. A sound originating in a membrane surrounded by air, as in the case of the drum, is better communicated to air than a dense medium, such as solid wood or the solid wooden stethoscope. The ribs and soft parts may be regarded as a thick membrane, particularly in wasted patients. But be this as it may, the fact remains that air-bubble rupture sounds, of which moist crepitation is a form, are better heard through hollow tubes than solid cylinders.

Since the above was written I have made some experiments upon vesicles of air and water, which fully prove the correctness of the views herein contained. Having blown air, by means of a tube, through water having soap in solution, and thus formed vesicles or bubbles, I have listened with the flexible and differential stethoscopes, which are strictly air instruments, and the sound of crepitation has been perceived far more distinctly with them than with the wooden solid stethoscope. With the latter instrument little is heard. If a mass of bursting vesicles be placed upon the cups of my differential stethoscope, loud crackles are heard, while little or nothing is heard when the wooden stethoscope is similarly dealt with. A piece of india-rubber tied over the mouth of the flexible stethoscope does not impair the sound. If the bubbles rupture upon it, the sound is rather increased. This membrane is analogous to the ribs and intercostal soft parts, which, as before remarked, may be regarded as a membrane, though a very thick one, and rather unfavourable to the preservation of the character of *air* sounds.

Humid crepitation, when dependent upon phthisis, for the most part commences at the apex of the lung. The very first part in which it more commonly makes itself known is above the clavicle. In many examples of phthisis, at the very commencement of the second stage, I have succeeded in hearing moist crepitation, though generally to a very limited extent only, above the clavicle and above the spine of the scapula, when moist crepitation has not yet become audible under the clavicle. The point at which moist crepitation next shows is beneath the clavicle and above the upper edge of the third rib. This is a region in which the sound is to be almost always heard when the patient is in an advanced period of the second stage of the disease. Soon after moist crepitation has become established above the clavicle, it is almost invariably heard beneath that bone, and more or less inferiorly: it is true that it may be absent or greatly reduced for a very short time. The scapular region is generally the seat of moist crepitation in the second stage of phthisis; but the cracks are here less easily heard: they seem more distant, and are fewer in number than in the corresponding part of the front of the thorax. The axillary region is a very common seat of moist crepitation in the second stage of phthisis. It is generally of a large character, and soon after it is first discovered it attains to a great extent, as if many air bubbles burst at the same instant, and during the whole period of inspiration and of expiration. Associated with the extensive humid crepitation of the axillary region, there is generally heard some moist crepitation in all the superior regions; but as the process of softening proceeds above, and as the tubercles are exspuated, as cavernules become caverns, and the third stage is developed in those upper regions, the moist crepitation often declines, and even altogether disappears or becomes inaudible, while this sign remains and holds in force in the axillary region. The tendency of the moist crepitation of phthisis is to spread from the apex to the base. At the apex it often departs or becomes inaudible; but this seldom occurs at the base, where it usually remains, and increases in amount in a remarkable degree in all examples of phthisis which tend to a fatal termination. The mammary region is early the seat of moist crepitation; but it may be slight, though the sign at the same time be strongly developed under the clavicle and in the axillary region.

The infra-mammary region is comparatively seldom the seat of much moist crepitation. It is frequently present, however, to a limited extent, after this sign has been some time established above. Moist crepitation obtains to a great amount in many cases of phthisis in the second stage in the inferior lateral and inferior dorsal regions. The inspiration sound consists, in fact, of a continued series of sounds proceeding from bursting water, or mucous bubbles or vesicles.

They are always of considerable size, and often obtain to a magnitude that entitles them to be called petty gurgling. It is very rare for the moist crepitation of phthisis in the second stage in these regions, to disappear; and when the third stage, or period of considerable-sized cavities, has been attained, this sign increases, and the sounds heard are those proper to larger water or mucous vesicles.

The moist crepitation of the second stage of phthisis, as a rule, commences at the apex, descends gradually to the base, showing a preference for the lateral and posterior regions. At the apex the sound sometimes disappears; in one series of instances followed by tubular, harsh, deficient respiration when a quasi-recovery is effected; and in another series of instances is replaced by cavernous, moist, or dry respiration sounds, and cavernous pectoriloquy when the third stage is attained, and the patient, for the most part, is doomed to an unfavourable termination of his disease.

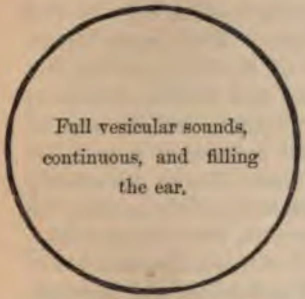
The above described order of the development of humid crepitation is generally observed in the second stage of phthisis, but it is occasionally departed from. It has been already stated that I have met with a case of phthisis marked with the signs of the third stage, viz., cavernous breathing and cavernous pectoriloquy at the base, in which signs of the first stage only could be detected at the apex. In this case signs of the second stage, including humid crackle, must have existed, and probably without the presence of the same sign in the superior parts of the lung. There was nothing to denote what occasionally takes place, viz., the cessation of this sign, for the percussion and vesicular sounds were not far from healthy at the apex, which could scarcely have been the case had humid crepitation once been developed. Similar cases, doubtless, do occasionally occur, but they must be rare, for the examination of those dead of phthisis at the Consumptive Hospital fails to give many instances of tubercular softening, or excavation at the base, without the usual appearances of softening or excavation being witnessed at the apex.

In a few examples of phthisis, apparently at the very commencement of softening of tubercle, I have occasionally observed that the humid crepitation has been first heard at the scapular region. A few humid crackles under the spine of the scapula have been heard, but they have been few; some three, four, five, or six occurring at different periods of the inspiratory act, that is, in succession, and at different parts of the space contained within the boundaries of the cup or the circumference of the stethoscope. A humid crack has been heard at one part of the stethoscopic region, another half an inch apart has succeeded, and others have followed here and there, or scattered about.

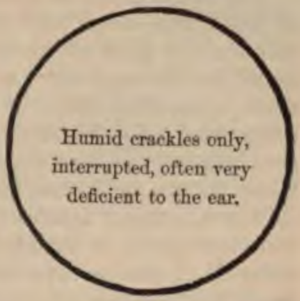
When humid crepitation sets in, it is usually to a limited extent only: some half-dozen crackles may occur under the stethoscope during inspiration. This lasts some weeks, or, it may be, months. It gradually increases, and after a few months it terminates in petty gurgling, or large cavernulous gurgling. In some examples, after humid crepitation has existed some weeks, or even months, it subsides, and terminates in simple tubular respiration. This subsidence I have noted to occur more particularly when the patient has been kept free from excitement, from exposure to cold air, from excessive talking; and has been, moreover, subjected to continuous and systematic counter-irritation. It has subsided not unfrequently after a patient has been admitted into our warm hospital, particularly in winter. When absent some time it recurs, in some cases, for a day or two, on one or more occasions on exposure to cold and excitement before it permanently leaves. Even in examples of phthisis, in which the disease progresses to the last stage, humid crepitation will disappear for a day or two, or become greatly reduced in loudness and regional extent, and the bursting vesicles will be fewer and smaller.

When humid crepitation sets in, the deficiency of vesicular respiration in the affected region is for the most part very marked, and is greater than it was in the first or mere crude tubercle stage. Until the moist or humid crepitation is very considerable, some quasi-vesicular sound may often be heard at the part, but it is coarse. At the same time the respiratory sound, both inspiratory and expiratory, is chiefly either of fine or coarse tubular respiration character. The vesicular respiration of adjoining healthy parts is full or even fuller than natural. When much humid crepitation is heard, and when it is very large, amounting to petty gurgling, no tubular sound is heard, and the only sound perceived denoting the act of respiration is a continued and sustained cracking during the whole of the inspiration and expiration periods. In this last case the coarse or merely deficient vesicular respiration sound, and the tubular sound of the more advanced period of the first stage are lost, and their place is taken by the humid crackling under consideration. The deficiency of vesicular and even tubular respiration bruits, in cases in which humid crepitation has been developed to some extent, is made appreciable to the mind by the employment of any kind of stethoscope, but by means of the differential instrument the reduction is rendered more particularly striking. With the wooden stethoscope we discover a considerable amount of humid crackling on the diseased side; on moving the stethoscope to the opposite side, if healthy, we perceive that the amount of respiration is greater, but the *difference* in the amount is much less satisfactorily established than when we employ the differential instrument upon the two sides simultaneously. When the sides are auscultated in the latter manner, the mind perceives a very curious series of phenomena. On the diseased side, a constant succession of crackles is made out during inspiration and expiration. The crackling sound also intimates that the air in motion is small in amount, and that the sphere of its motion is very limited. On the healthy side full, loud, vesicular, lung-expanding sound is heard. The amount of air seems to be large, and the extent of its motion great, while its course is free, yet moderately resisted in the healthy expanding vesicles of the lung. The contrast is very great, and to the mind of every one who has realised it, has been acknowledged to be very striking, and to afford a ready and convincing proof of the great extent of the disease, and of the great anatomical difference of the two sides of the chest, such as is not to be obtained by any other known means. The two sets of sounds are distinctly heard: one in one ear and one in the other, at the same moment, one set by no means interfering with the audition of the other. On the contrary, they materially aid, as it were, in the audition of each other, for the contrast occurring at the very instant of the audition of the two sets, is perceived to be very striking. Though the differential instrument is thus very advantageously and interestingly employed simultaneously upon the two sides of the chest, or upon any two parts, the acoustic properties of these may be very conveniently ascertained by the examination of one part after another by means of this contrivance. When the differential instrument is employed simultaneously on two sides of the chest, one lung being in a state of softening, marked with humid crepitation, and the other lung being healthy, the following diagram represents the sounds which are heard through the cups of the instrument respectively.

Healthy lung.



Softened lung.



The size of the liquid vesicles, whose rupture gives rise to the sounds called liquid or humid crackling, seems, as judged of by the sensation conveyed through the ear, to be somewhat various in different cases of the disease, but the range is not great. The size thus judged of appears to be generally that of a swan shot or of a coriander seed. Not unfrequently the size of the vesicle appears to be that of a garden pea, but this is generally when the softening is far advanced. At the very last period of softening, when the lung is breaking up into cavernules, and just previous to the formation of considerable-sized cavities, the vesicles appear to be as large as horse beans. The humid crackling then takes on the character of petty gurgling. The cavernules referred to and existing when this petty gurgling is heard, are generally the size of horse beans. They may be larger, and may attain the dimensions of a hazel nut, but this sized cavity is liable to lose its sounds, such as proceed from a smaller cavernule, if partially filled, as often happens, with softened tubercle and muco-purulent or sero-muco-purulent fluid. As the second stage progresses and reaches to the third, the humid crepitation increases in numerical extent, in size, and in loudness.

The humid crepitation of the second stage of phthisis, sometimes becomes exceedingly abundant, and the sound heard is that understood best by the term "squashing." The vesicles are numerous and large, the amount of liquid is great, and there is generally present under such a condition of sound a more than usual amount of inflammatory action in the diseased part. I have heard this sound most frequently in children and in young adults. I have heard it more frequently in delicate young women than in men. It is a conclusive test of the presence of phthisis, mostly in an active form, and almost invariably indicates a rapid progress of the disease, and a speedy and fatal termination.

The mechanism of humid crepitation or crackling admits of ready exposition, and indeed suggests itself at once to the mind of the most unpractised auscultator. The sound is produced by the rupture of a membrane of liquid, more or less thick, consisting either of mucus, blood and mucus, or of pus, serum and softened tubercle. The membrane or film may be a mere partition, occupying a terminal tubule, or a penultimate tubule, or it may be, as is the case almost invariably in the advanced second stage, a spherical vesicle occupying the same parts, or situated in a cavernule, the late seat of a tubercle, or two or three tubercles. The mere film crackle is heard only at the very first period of softening, and is much more like the dry click of the first stage of the disease than the crackle or crepitation of the spherical vesicle. The film crackle is heard when a certain amount of over secretion is present in the ultimate or penultimate tubule, and closes the tube; the air inhaled comes in contact with this liquid, which, with the advancing air, forms a fine film. This at length bursts, a little explosion takes place, the air passes on, and the liquid is dispersed along the walls of the tubule; a single crackle thus takes place in the tubule. If another tubule be so situated, a second crackle is heard, and for each tubule so placed a distinct crackle is obtained. During expiration the tubules are somewhat compressed, and at its termination the liquid again comes in contact from the different parts of the circumference of the tube, and a partition of liquid is again formed. This during the act of inspiration is again ruptured, and again we have the crackle, and if many tubules are so placed, we have then many distinct crackles. This is a very early and ill-formed kind of humid crepitation: it is soon converted into another kind, if the process of softening be not arrested.

The amount of excited, vascular, or inflammatory action is so great as to produce secretions, which form and collect in mass, this over-action being induced by the presence of tubercle, and sometimes aided by the accidental operation of other causes, such as exposure to cold. A single membrane, or liquid partition, is not now formed, but we have a collection of liquid consisting of pus, mucus, blood, or serum, or of some or all combined; and all air passing towards the lung vesicles, or to the last pervious tubules of the lungs, must pass through these liquids. Air thus passing through liquids conveyed by small tubes almost invariably forms into vesicles, and in doing so produces bubbling sounds. The vesicles are proportioned to the size of the tube by which it reaches the liquid, and to the velocity of the motion of the air, and to the tenacity and thickness of the liquid. These vesicles burst in tubes, pulmonary cells, or cavernules filled more or less with air; a sound of explosion is produced. These sounds constitute humid crepitation. A continuous current of air from a tube, when it reaches liquid, and is made to pass through it, ceases to be a continuous stream: it divides into numerous parts, which assume the form of spheres. These spheres reach the surface of the liquid, and come into contact with air. The escaping air carries with it a film of liquid, which immediately bursts. The air so contained is somewhat compressed, and the air being liberated expands suddenly, comes into rather active collision with the edges of the ruptured vesicle and with the surrounding air, and the sound under notice is created. I have found that air blown with the force of natural expiration through a tube the one-thirtieth of an inch in diameter, and made to pass into water, forms into a series of spheres or vesicles about the size of a coriander seed. Air passed through a tube the one-tenth of an inch in diameter gives vesicles the size of peas and beans. When the motion is slow, the vesicles are small; when rapid, the vesicles are larger. The size of the tubes now referred to, are nearly the size of the ultimate and penultimate tubules, and the size of the vesicles described is much the same as those which we are led to believe produce the sounds which we hear at the different periods of the second stage of phthisis, the larger vesicles affecting the latter end of it. The size of the tubes and cavernules chiefly determines the size of the vesicles; and as in phthisis the parts essentially affected are the vesicles and terminal and penultimate tubules, the sounds denote small, or rather small, vesicles, such as have been described. But as bronchitis is often associated with this disease, we frequently have larger crepitation in the course of the larger tubes of the primary bronchi, heard over their seat, but less commonly in the second than the third stage. If cavernules are tolerably large, and contain air, the vesicles which form may be the size of peas or beans; but much will depend upon the tenacity of the secretion which the entering air meets.

It is of importance to mention, that very fine tubules, such as the terminal bronchi, are rather unfavourable for the formation of air vesicles that shall rupture within them, and that the liquid which they contain, unless it is tenacious and thick, and adhering strongly to the walls of the tubules, it is very apt to be itself carried in mass in front of the air which enters. Therefore, unless the respiratory movements are quick, the air may pass to and fro with the little column of liquid in front of, or behind it, without the liquid being penetrated, and, therefore, without bubbling or rupture sound. To be satisfied of this, pass water into a glass capillary tube of the one-hundredth part of an inch in diameter, then gently blow a little air into it. It will be observed that no bubbling or rupture takes place in the tube, and that this occurs only at the open end of the glass. The water passes along in front of the air, and it is only when it reaches the extremity that the water, refusing to leave the glass altogether, is forced out into a fine membrane, and that it is now ruptured by the advancing air. If, however, the liquid be tenacious, like honey or thick mucus, a rupture will take place in the tube itself; for the advancing air is unable to carry the whole of the liquid with it on account of its tenacity, which causes it to attach itself to the walls of the tube. The liquid is borne forward, but gradually becoming smaller in quantity, so that at last only a thin membrane is left, which is easily ruptured in the tube, and a crackle, loud, grave and coarse, is now heard. If the amount of liquid, however thin, contained in a capillary tube, be small in amount, the air coming in contact with it may succeed in passing through it, for some of the liquid is always left in contact with the walls of the tube: it may be thus expended, and at last only sufficient may be left in front of the moving air to form a membrane, which shall now be soon ruptured with the result of a cracking sound proportioned to the size and thickness of the membrane which has been rent asunder. These sounds may be imitated advantageously by blowing air through honey, water, and other liquids.

The sound of crackling is much modified by the thickness of the liquid which takes part in its formation. If thin and watery, the sound is quickly obtained: it is clear, and of short duration. If, on the other hand, it is thick and tenacious like honey, it is slow of production; it is of long duration, and the note is comparatively grave. The latter is the condition which we have in the latter end of the first stage and at the commencement of the second stage of phthisis. When a cavernule has formed, and the liquid or secretion is tenacious, we have then a grave, slow explosion, as it were of some size, something like the sound of a slow puff made into a small air chamber with thick walls. When the secretion is very thick, and is contained in tubes of no great size, it may succeed in obstructing all respiration through the part; sometimes it only partially obstructs the passage of air: the secretion is partially broken through, perhaps by a very small orifice, either round or mere slit-like, the air that passes is thrown into strong vibrations, and, at the same time, the walls are likewise made to vibrate, and we have a sound of sibilus or cooing, or snoring, or hissing, according to the circumstances of the case. All these observatious are founded upon actual experiments. To produce these latter sounds, the tubes must possess more firmness and resistance than the terminal tubules.

When in the second stage of phthisis, we have much watery secretion, as well as a good deal of air, in rapid motion, much thin liquid, sharp and large crepitation, is heard. The heart's movements will frequently succeed in mixing up intimately the air and water contained in cavernules, and give rise to much of this sign. An augmentation of the crepitation is thus found to be synchronous with the heart's movements.

The diagnosis of the humid crepitation of phthisis in the second stage, from similar crepitation of other diseases, will be much aided by the consideration of the history of it just given. The mucous râle, or the crepitation of bronchitis, with copious secretion, is usually associated with healthy percussion and with full inspiration and expiration, while in phthisis the humid crepitation is associated with dullness on percussion, and extremely defective respiration, made very obvious by means of the differential stethoscope employed simultaneously on the two sides of the chest, or upon a healthy and an unhealthy part. In phthisis the humid crepitation sounds are nearer the surface than in bronchitis. In bronchitis the crepitation is very frequently heard on both sides, and to a nearly equal extent, while in phthisis, for the most part, it is confined to one side, or is very greatly more developed on one side than on the other. The decline of the health, the gradual wasting, and the hectic symptoms proclaim phthisis.

The voice, also, is a valuable test, for it is very generally augmented in the softening stage of phthisis. It is, however, to be borne in mind, that the voice is sometimes weaker on the diseased side than on the healthy; this arising from two causes, one being real deficiency, from impervious tubes; the other being increased voice on the healthy side, from increased respiratory activity.

It is scarcely necessary to say that the fine crepitation of pneumonia is easily distinguished from the larger humid crackle of the second stage of phthisis. Pneumonia crepitation is very fine, and when very small, as it usually is, has a dry character, like the sound produced by rubbing a lock of hair between the fingers, as has been well described by Dr. Williams. What has been called sub-crepitant rhonchus is more liable to be confounded with the humid crepitation of phthisis, for it is a moist sound, it seems to proceed from the rupture of air vesicles of some size, such as that of small shot, but greatly less than the size of the ordinary humid crepitation of phthisis. This sub-crepitant rhonchus, as it is called, or as it might perhaps be more advantageously designated, fine liquid crepitation of bronchitis and declining pneumonia, though different from the ordinary humid crepitation of phthisis, physically differs only in size. Though different, it frequently attends the phthisical sign, as when inflammation attacks the vicinity of tubercle.

The humid crepitation of phthisis in the second stage is heard at first chiefly during inspiration, when it more especially consists of distinct crackles; but when it is abundant and continued during inspiration, it is nearly equally strong, extensive, and continued, during expiration. During the period of respiratory rest, the humid crepitation generally ceases: if heard, it is in single small explosions, occurring separately and in succession.

The crepitation of the second stage of phthisis is occasionally heard to be augmented at the period of the heart's systole. Additional crackles, generally of a large size, are heard at the moment of the heart's contraction, but this cardiac increase is almost exclusively noted in the second stage, when the humid crepitation has reached to the degree I have ventured to call petty gurgling, and when the lung is laden and saturated with liquid in cavernules.

In the second stage of phthisis, humid crepitation is the only entirely new physical sign superadded to those which are found in the first stage. While we have this new sign in the second stage, some signs which were observed in the first, are greatly reduced, or are totally lost. The tubular and the harsh respiration, the simple prolonged expiration may be found, while the moist crepitation is not very considerable, and is still insufficient to mask these signs, which is generally the case for a considerable time,—some weeks, or even months, in chronic phthisis, and a shorter time in acute phthisis. At the end of the second stage these first stage signs are not usually to be recognised, i. e. at the seat of the softening, the humid crepitation sufficing to obscure and sensorially silence all other respiratory sounds.

If the acknowledged and coarser auscultatory signs of the first stage of phthisis are successfully masked or silenced by the loudness and the heterogenousness of humid crepitation, the reader will be prepared to hear that the finer signs which occasionally precede them, and also accompany them, to which reference has been already made, are also sensorially silenced. If they are heard it is in another spot, either on the opposite side or at the base of the affected side, and not in the originally diseased part. The fine sounds to which we allude are those described when we were treating of the first stage, under the titles of buzzing, humming, arrow-root, yarn-tearing, fine rolling, and shell bruits.

While the coarse, the feeble, and the defective respiration of the first stage are lost to the ear in the parts now in a state of softening, these signs very frequently invade other parts. As soon as material softening with humid crepitation is established at one apex, the respiration on the opposite apex becomes coarse, rather full from a compensatory action, and the expiration is prolonged. This arises partly from the deposit of tubercle, and partly from a scarcely morbid hypertrophy of the pulmonary cells. The thoracic voice also I have remarked to become stronger. But it is at the middle and the base of the lung primarily diseased that the signs of the first stage show themselves, and they very generally do this. The respiration becomes harsh, deficient in fulness, and mixed with a little sibilus or arrow-root, or fine rolling bruits, and the expiration is greatly lengthened, and rendered more noisy. The chief auscultatory sign noticed at the base is the great and marked deficiency which we detect almost uniformly with the differential stethoscope. I have seldom placed the cups of this instrument upon the two bases in cases of softening at one apex without being made fully, and almost strangely, aware of a great deficiency at the base of the softened lung. The difference is so great that the base of the softened side is sensorially silent, while the other is sensorially loud, with full vesicular respiration. The diagram subjoined illustrates these facts. The black figure represents sound, the dotted figure represents sensorial silence.

Healthy base.

Unhealthy base.

Since the above account of the history of humid crepitation was written, I have met with an interesting specimen of this sign, which is very instructive, and which, on account of the importance of the questions to which it relates, is well worthy of special notice here. It would seem to imply that humid crepitation of the second stage of phthisis may more frequently begin at the base than the previous observations in this work would suggest. ——, male, aged about thirty, came into the Paget ward of the Hospital for Consumption some ten weeks ago (May 1860). At that time he was pallid, weak, short of breath, thin, but not rapidly wasting. He had slight albuminuria. Percussion of the chest was medium; very considerable moist crepitation existed at the right base, and there only. It was concluded that the case was one of humid bronchitis, in a great measure dependent upon, or connected with, disease of the kidney. He was examined again some weeks after, when the same signs were once more made out. This patient was again examined very lately, and it was found that the moist crepitation now existed to a very considerable extent at the right apex; that the right shoulder had very materially fallen; and that there were present both deficiency of respiration and dullness on percussion over this part. The respiration was also deficient at the base, as indicated by the differential stethoscope.

This case is certainly one of phthisis, and it serves to argue that the process of softening may commence at the base and proceed upwards. The general lesson may be also derived from this case, that it is desirable to examine our patients from time to time, for to old signs new ones may be superadded, or the old may have new sites, as in this case, and, in consequence, our views of the disease may be much qualified. The prognosis, as well as the diagnosis, may much depend upon this additional evidence. The treatment, considered in a wide sense, may likewise be immensely modified by this addition to our knowledge.

CHAP. XX.

SECOND STAGE—*continued.*

Thoracic Voice increased.—Locale.—Reduced thoracic Voice: due to Occlusion of Tubes.—Stronger Voice on healthy Side.—Value of differential Stethoscope.

THE thoracic voice is affected abnormally in a larger proportion of cases of phthisis in the second stage than in the first, and the abnormal alteration is increased in the second stage in a large number of those cases in which it had been ascertained in the first.

A small proportion only of examples of humid crepitation, occurring in the second stage of phthisis, are met with in which the voice is not more or less intensified, and partakes of the large tube character designated bronchophony, and which, besides seeming to originate in a tube, and to preserve its original character, has a quality which denotes that it proceeds through a solid body of the density of a full half inch, in more or less vibration, before reaching the walls of the chest.

In some examples of phthisis, the increased distinctness of the thoracic voice, the force, the vibration, and the tubular character, are not distinctly perceived until the disease has reached the second stage, or that of softening denoted by humid crepitation.

The locality of the increased intensity of thoracic vocal resonance is generally co-extensive with the softening.

The locale is usually more extensive in the second than in the first stage, for while the softening of the original disease is taking place, fresh deposition is rapidly progressing in hitherto healthy parts, now becoming the seat of increased vocal resonance. The intensified, as well as the peculiar thoracic voice, is heard in the supra-clavicular, the clavicular, and infra-clavicular regions. It is also heard above and over the scapula, and when the stage of softening is advanced, and when deposition of tubercle is taking place at the base, laterally or posteriorly, this sign is likewise found in these regions.

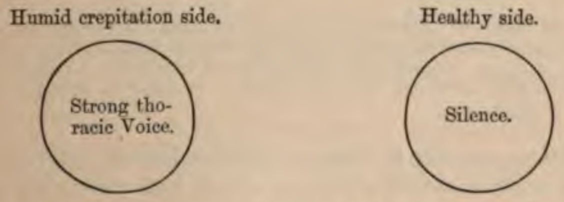
But while increased vocal resonance is generally present in phthisis in the second stage, and proves to be a confirmatory sign of some value, it is very proper to mention that it is not by any means invariably an associate of this condition. This sign was present at the apex, in perhaps 80 per cent. of the cases I have examined. I have detected it in three examples, the only ones I have examined, to-day (June). But within the last few days I have seen some examples of humid crepitation in phthisis, in which the thoracic voice was stronger on the healthy than on the unhealthy side. The greater intensity has not been confined to the right side. In these examples of stronger voice on the healthy side, I incline to believe that this preponderance has been of only recent duration, and that it was preceded by the same sign on the unhealthy side of the chest. It is only in old-standing examples of humid crepitation, or in recent examples, marked by rapid destruction of the tissues, and infiltration of liquid into the bronchial tubes, that the thoracic voice preponderates in loudness and force on the healthy side. In such examples, I believe that the bronchial tubes, communicating with the diseased and softened parts, are obstructed, either by liquids, or by thickened mucous membrane, or by fibrous exudation, or by pressure from the hardened pleura, or even from the thoracic walls, or that they are becoming closed from the paucity of air the lung can accommodate, and that the volume of air bearing the voice, reaching to the diseased parts, is insufficient in amount to communicate sonorous vibrations to the lung and to the thoracic walls in abnormal force. And it is to be observed that while this process of occlusion of the sound-conveying tubes is progressing, a contrary or opposite operation is going forward in the opposite lung, where puerile or compensatory respiration is being established, and the bronchial tubes are being more than usually filled with air ready to receive from the larynx the vocal sounds, and to convey them to the lung, and thence to the thoracic walls. I incline much to the belief that when the voice is stronger on the healthy side than on the unhealthy, humid crepitation of the second stage being present at the spot, the conditions above named are present. But I have no doubt whatever that when the increased vocal resonance is present on the healthy or resonant and full breathing side, humid crepitation being heard on the opposite side, it will be found in many cases that the disease has really reached the third stage, masked for the time, and is no longer in the second. The humid crepitation exists now in bronchial tubes only, and nearly all voice-conveying communication is abolished between the trachea and the cavity in the lung, or the cavity and the bronchial tubes belonging to it are nearly or completely obliterated.

In such examples of preponderance of the voice on the healthy side, I have generally found marked depression and contraction of the thoracic walls, great deficiency of respiratory sounds, and defective expansion on the reduced voice and humid crepitation side, while the opposite, or intensified voice side, has been remarkable for full motion, elevation, resonance and full noisy vesicular sound, indeed, for puerile respiration, beautifully indicated by the differential stethoscope.

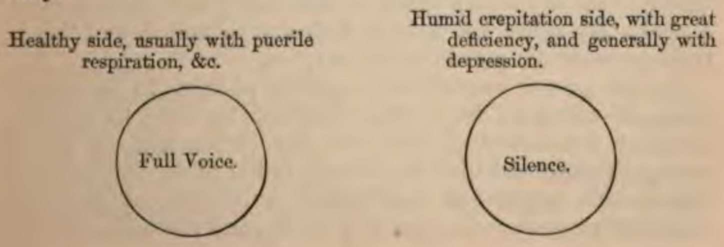
But for one example of deficient voice on the diseased side at the apex, I have found at least two in which this deficiency existed at the base. I have now under my observation some examples of marked deficiency of voice at the diseased base, in the second stage of phthisis. The tubes there are smaller.

The fact that the voice is occasionally heard stronger on the healthy side than on the other, under these circumstances, is calculated to lead to errors in diagnosis. I have known the healthy lung to be taken for the seat of the greater disease than the lung in which moderate humid crackling has been present, because it was the seat of an intensified voice. It is therefore well not to regard a strong voice as always the sign of disease, and a weaker voice as the index of health; for under the circumstances mentioned these signs indicate the reverse.

The preponderance of the voice on one side in the second stage of phthisis, is admirably exhibited, as it were, to the mind, by means of the differential stethoscope, employed bilaterally at the same moment. The following diagram represents the voice as it is usually found in the humid crepitation stage of phthisis.



The subjoined diagram represents the voice distribution in those cases in which the voice is heard on the healthy side only.


Healthy side, usually with puerile respiration, &c.
Humid crepitation side, with great deficiency, and generally with depression.
Full Voice.
Silence.

It is to be observed in estimating the value of the distribution of the thoracic voice, that the natural voice is almost invariably stronger on the right side than on the left. When, therefore, the greater intensity is found on the left side, it is more especially a sign of disease being present.

The voice intensification at the thorax, in the second stage of phthisis, where softening is progressing, depends upon this:—the sonorous undulations are, as in the first stage, retained more than usual in the bronchial tubes, and are prevented becoming diffused and broken up and dispersed through the normal subdivisions of the bronchi and through the pulmonary vesicles. They are retained, and have such force that they throw the walls which enclose them into unwonted vibrations, and these vibrations are communicated to the walls of the thorax. The cavernules too, which form at this stage of the disease, though only of the size, it may be, of peas, or beans, when seated near the surface of the chest, serve to conduct the voice to the ear.

CHAP. XXI.

SECOND STAGE—*continued.*

Auscultatory Signs of intercurrent Diseases.—Pneumonic Crepitation.—Subcrepitant Rhonchus of Bronchitis, &c.—Questionable Title.—Proposed Classification of moist Crepitations.—Puffing Sound of bronchial Congestion.—Pleural Sounds.—Arterial thoracic Sounds.—Pericarditis Sounds.—Endocardiac Murmurs, &c.

As phthisis progresses, various diseases become superadded, and add to the auscultatory signs which had previously been discovered. The pleurisy and the pneumonia, which were noticed as occurring occasionally in the first stage of the disease, are much more frequently superadded in the second. These secondary or engrafted diseases bring with them certain auscultatory signs which it is desirable to notice, and this is the most suitable place for the purpose.

To the proper auscultatory signs of phthisis in its second stage, of which we have been treating, we have to add the frequent occurrence of fine vesicular crepitation of pneumonia, the fine vesicular liquid crepitation of declining pneumonia, the larger yet fine liquid crepitation of capillary bronchitis, the friction signs of pleurisy, and the ordinary "to and fro" churning sound of the exudation and secretion of common pericarditis, &c. All these signs occur occasionally in the second stage of the disease, but they show themselves, as we shall presently see, much more frequently in the third.

The fine vesicular crepitation of pneumonia is the frequent adjunct of the signs proper of phthisis in its second stage. Perhaps it may be called a sign proper in itself, for the occurrence of pneumonia in the course of this stage of the disease is almost unavoidable. Intercurrent pneumonia, as it is called, occurring in the course of pneumonia, after the completion of the first stage, may be almost always discovered if attention be paid to its signs. The breaking down of crude tubercle into the softened material, and the destruction of the neighbouring vesicular tissue, almost includes this disease; and if its signs are not marked at all times, this depends much upon the fact, that the signs, fine as they are, are masked by the much more noisy bruits of the large liquid crepitation of the parent disease. But in addition to this accession of pneumonia in the immediate vicinity of tubercle that is softening, this acute disease very generally breaks out in the middle and at the base of the affected lung. As evidence of this, it may be mentioned that, in very few of the bodies examined at the Hospital for Consumption, have I found a lung free from pneumonic consolidation, in which softening of the lung had occurred, even though confined to the upper lobe.

The lung is generally firm, reduced in its proper crepitation, reddened unduly with blood, and its penultimate tubules are, for the most part, distended with sanguinolent serum exceedingly frothy. If these tubules be pressed they discharge much frothy liquid.

The physical sign of pneumonia in this complication, as well as in pneumonia occurring primarily, is the fine crepitation of authors. It has been likened by Dr. Williams to the sound produced by rubbing a lock of hair between the fingers, and the comparison is not an unhappy one. To me this sign has generally appeared to be, so to speak, a larger sound, i.e. as if proceeding from larger bodies than hairs, and it has seemed to have more of a liquid character than the hair friction sound. This pneumonic bruit is very closely imitated by the explosion of the very finest bubbles obtained by the effervescence of carbonate of potash, listened to through the differential stethoscope. It is also very like a sound which is more nearly allied in its origin to pneumonic crepitation than the hair sound, viz., to the sound produced by blowing air through a number of capillary glass tubes of the finest description, that will simply admit a hair, wetted with water at the further extremity, i.e. the extremity held in the air. When tubes are so treated, bubbles of air and water, about the size of millet seeds, will form; they then explode and crack. A succession of these cracks is precisely the sound of the fine crepitation of many cases of pneumonia occurring in the second stage of phthisis. The liquid in the lung, which is thickish serum, is evidently drawn to the cell extremity of the bronchial tubule; the cell is expanded in the act of inspiration; the liquid, partly retained in the tubule and partly carried to the mouth of the expanded cell, now forms a minute vesicle or membrane, which is ruptured by the advancing air. The serum, after the passage of the air into the cell, again closes the tubule, immediately another vesicle or membrane bursts, and with the same noise. Complete bubbles, unburst, are besides carried backward and forward, and are prevented bursting for a time by the tenacity of the liquid which films them.

The usual seat of pneumonic crepitation in phthisis, as when pneumonia occurs primarily, is at the middle and base of the lung, and at its posterior and lateral aspect. When pneumonia occurs in the second stage of phthisis, it is almost always in the same lung; but occasionally it occurs in the opposite or healthy lung also. When it occurs in the opposite or non-tuberculated lung, the general distress is great, and the dyspnœa is excessive and greatly endangers life. In almost all cases of phthisis in which death takes place in the second stage, some degree of pneumonia, there is reason to believe, has existed.

An access of pneumonia in the middle and base of the lung occurs from time to time in many examples of the second stage of the disease. The acute condition, marked by considerable fine crepitation, lasts for nearly a week. The same thing may occur again in a week or two, but as the cells and tubules become obliterated by hepatisation, the same amount of frothing crepitation is not found, and the crackling assumes the size of what has been called sub-crepitant rhonchus, which is a bubbling sound, proceeding from air vesicles rupturing as in the other instance, but of a larger size, and often found in, and generally held to be a sign of, bronchitis, called capillary.

It may be stated that, in nearly all examples of advanced softening in the second stage of phthisis, pneumonic crepitation exists for a time, or may occur from time to time, at the base of the softened lung.

The same sign has been heard by me in the opposite lung in about one case out of ten.

The sign generally designated sub-crepitant rhonchus is an almost constant attendant upon phthisis in the second or softening stage. It is found not only in all cases, but for the most part at all periods of this stage, from the commencement to the conclusion. This sound is the product or result of the rupture of air and liquid vesicles, and differs from the fine crepitation of pneumonia in this, that it is much larger; and, from the humid crepitation of phthisis in this, that it is smaller. The sub-crepitant rhonchus holds, in respect of the size of the vesicles from whose rupture it proceeds, a middle position between pneumonic and pure phthisical crepitation. It differs, too, from pneumonic crepitation in this, that it is a more liquid and more clearly bubbling sound; while it differs from the crepitation of phthisis in its softening stage in this, that it is less coarse, less grave, and to be less individualised, so to speak,—that is, separated into single explosions. The crackle of sub-crepitant rhonchus is generally the explosive sound of a liquid or watery vesicle the size of small shot, while that of pneumonia is that of a vesicle the size of the smallest millet seed, and that of the softening of phthisis of a garden pea, or of a coriander seed at least. The sound in sub-crepitant rhonchus seems to be composed of very many explosions, while that of softening is not always very multi-vesicular. Even when many explosions occur in softening, they are nearly single at a time, and come in succession, though in some cases, rather rapidly. The explosions in pneumonia occur in thousands.

The character of the crack in the sign under description is much that of a watery vesicle, while that of softening is more that of a denser liquid, and may be successfully imitated by forming vesicles of honey, or of syrup, or of thick mucus.

I have heard auscultators say, by way of facilitating the diagnosis of the crepitation of softening from that called sub-crepitant, that the latter had a metallic quality. When the liquid which goes to the formation of the vesicles of sub-crepitant rhonchus is very watery, the rupture of the bubble certainly does possess a quasi-metallic character; but I believe it will be simple and more natural to say at once what is really the case, and give an absolute instead of an approximate or allied picture or expression. It is a watery, or a water vesicle sound. To know what a watery sound is, it is only necessary to listen to the bursting of a water vesicle, and the sooner the auscultator knows simple absolute characters, the better it will be for himself and his patient.

For the sake of precision, I believe it would be well were auscultators to dispense altogether with the title,—subcrepitant rhonchus. The word rhonchus was by the Romans employed to mark a dry sound. By most physicians the word is so understood. To the prefix "sub," there is also an objection, applied in connection with pneumonic crepitation. It seems scarcely correct, for it is not an under or smaller sound, as would naturally be supposed by those ignorant of the sign, but acquainted with the value of the preposition "sub," would suppose. It appears to me that precision would be greatly promoted were the liquid crepitations arranged in one class. This class would be naturally divided into three groups: first, the fine liquid crepitation of pneumonia; secondly, the larger liquid crepitation of capillary bronchitis and of pulmonary hæmoptysis, which is the sign under treatment; and the large thickish-sounding crepitation of softening tubercle and bronchitis. These might be respectively called fine, medium, and large crepitation. It is true that there is another form of liquid crepitation, viz., gurgling. Gurgling, though dependent upon the formation and explosion of vesicles, though it is true, very large, yet has so distinct a sound from the signs above treated of, that it would be excusable, natural, and useful to arrange it by itself or to separate it from simple liquid crepitations. It has a sound as if much air and water were mixed together. Gurgling again might be divided usefully into two kinds, differing perhaps more, it is true, in degree than in nature, either in respect of sound or of origin, viz., first, petty gurgling as in cavernules; and secondly, into large gurgling as in caverns. These five sounds include all that would practically claim to be liquid crepitation sounds. The liquid crackle into a large air chamber, such as a large vomica, or in the pleural cavity in pneumothorax, is so distinct, that its characteristic metal tinkling sound may be passed over in a classification applicable as on the present occasion to the common liquid crackling signs of disease. The peculiarities of such vesicle explosions will be treated of afterwards. The metallic tinkling in cavities is most commonly due to the explosion of air and water bubbles or vesicles situated at the narrow entrance of these chambers, sometimes to the explosion of a vesicle in the interior. The thin walls of the cavity consonate, as in pneumothorax do the walls of the chest. But I am reminded that this is a digression, though a justifiable one, on crepitation in general, in a place strictly devoted to the consideration of the humid crepitations of phthisis in its second stage.

Sub-crepitant rhonchus, or as I have proposed to designate it, medium liquid crepitation, is the associate and the dependent of the bronchitis that is called capillary, or of fine tubular bronchitis. This bronchitis may be either acute or chronic, attended with acute symptoms, or, as is more generally the case, with little general disturbance. This medium liquid crepitation is sometimes the consequence of simple over-secretion of the finer tubules in the second stage of phthisis.

The locality of this medium liquid crepitation is twofold:—First, it may appear in the vicinity of the softening tubercle or breaking-down lung. Secondly, it may make itself heard at a remote part as in the middle and the base of the lung when the softening is proceeding at the apex.

At the apex, after softening has proceeded some way, this sign is very liable to occur, and it is apt to recur from time to time on the accession of every increase of vascular action in the mucous membranes from exposure to cold. As the process of softening proceeds, and the patient becomes exhausted, the repetition of medium liquid crepitation is more frequent. If the patient is not cut rapidly off by means of some accident of great urgency, it is almost always present at the conclusion of the patient's last sufferings. At first this sign lasts only a few days, but towards the conclusion of the disease, it becomes persistent during the last hours of the patient's life.

This liquid crepitation, when originating above, usually descends rather quickly towards the middle and the base of the lung. Sometimes the medium crepitation of the softening stage will disappear under the influence of counter-irritants; and if dependent upon a chronic over-secretion, upon the administration of squills and blue pill and stimulating expectorants. This sign when largely manifested and persistent is ominous of a fatal and early termination of the disease.

The flexible or air instruments are well calculated to render audible this form of crepitation.

This form of crepitation, combined with some fine or small crepitation, is almost invariably developed in the occurrence of considerable hæmoptysis from the lung. The bloody sputum indicates the nature of the crepitation. This form of the medium crepitation, which is heard in the softening stage of phthisis, is generally audible below the rest of the softening. The blood, when it is extravasated, seeks the lower parts of the lung. If much hæmoptysis occurs, larger bronchial râle or petty gurgling may be heard for a time in the larger bronchial tubes.

This medium crepitation is very generally heard when, in addition to softening tubercle, œdema presents itself in the base of the lung, a common occurrence in old subjects; in those suffering from obstructive disease of the heart, particularly on the left side; from Bright's disease, or from anæmia and dropsical affections in other parts. When the medium crepitation which is present, depends upon œdema, it is more generally heard on both sides of the chest, than when it is the result of hæmoptysis or capillary bronchitis.

A sound has been occasionally heard by myself at an early period of the second stage, and also at an advanced period of it, but in a part just beginning to discharge its tubercles. The sound is a dry puffing one, as if air were suddenly *puffed* after some resistance from thick materials into a small dry chamber. It depends upon the presence of bronchial congestion. It has been heard chiefly at the scapular and subclavicular regions. There has generally been observed from time to time a sonorous long rhonchus, indicating a congested or narrowed state of the bronchial mucous membrane; but the sound I refer to is totally different from this. It is exactly as if a small bronchus were closed either by congested walls, or by the pressure of adjacent tubercle, and were forced open, and a *puff* of air was made with some force into a cavernule the size of a bean. I have observed that this dry *puffing*, if I may use the term, has been heard only on deep inspiration, and the *puff* has taken place towards the close of the act, when, as it has appeared, the air has penetrated a considerable way into the lung structure, and has suffered some retardation in its course. I regard this sign as of some value when the moist crepitation is not much marked, and when the percussion sound is not sensibly affected. It may be conveniently called a dry puffing sound or a puffing cavernulous sound.

The sonorous and sibilant rhonchi of bronchitis are not unfrequently strongly developed in the second stage. They seldom however mask moist crepitation. They have received considerable notice in the first stage.

The friction sound of pleuritis is a common sign in the second stage of phthisis. It has been frequently described by authors. I incline to the belief that it is not so commonly heard as some practitioners believe, for it is a fine, low sound, and is readily masked by the coarser sounds of the second stage. I am convinced that when fine or medium crepitation is established at the middle or the base of the lung, or when the respiration is very harsh or blowing, pleural friction sound is not to be heard except when it attains to its coarser degrees. Pleural friction sound takes place when the pleura becomes dry and rough. The first stage of the sound resembles the noise produced by passing fine silk or satin over another piece. It is rather interrupted, as if, after some degree of harsh sliding had taken place, the sliding were suddenly suspended and again suddenly renewed. This sound of dry interrupted friction, proceeding from a dry, slightly roughened condition of the pleura, is generally heard best at the lateral and inferior dorsal regions. It is there that most locomotion of the lungs takes place. The dry condition of the pleura, which gives rise to this sound, is common at the commencement of pleuritis, but I have reason to believe that excited action in the lung, short of inflammation, will frequently give rise to it without genuine pleurisy being subsequently established. When the exudation of lymph upon the pleural surface is considerable, and prior to its producing attachments, and antecedent to that amount of serous secretion that separates the pleura costalis from the pleura pulmonalis, a coarser sound may be heard. When this lymph becomes comparatively hard and resistant, when it becomes cartilaginous, which it sometimes does, but more frequently it is true, in the third stage of phthisis, than in the second, a grating sound very different from the fine friction sound we have been describing is produced. It approaches the sound of a smooth bone being slowly rubbed upon another bone. This sound I have heard, and it has masked all ordinary respiratory sounds. It is proper to observe, that while these rather extraordinary sounds are heard at the middle and base of the lung, chiefly posteriorly, the ordinary signs of softening are still developed in an unmodified manner at the apex.

When effusion takes place to some considerable extent in the pleura, other signs come under notice. I have seen several examples of phthisis, in the second stage, in which effusion of serous and sero-purulent liquid, having occurred to some considerable extent, the following signs have been manifested. 1. Ægophony. 2. Suppression of respiration sounds and voice at the most dependent parts of the side. 3. Increase of dimension, with bulging or protuberance of the intercostal spaces. But as these signs occur more frequently at a later period of the disease, I shall here content myself with this brief reference to them, and deal with them more at length at a subsequent part of this work.

The systolic arterial sounds noticed as occasional attendants upon the first stage of phthisis, are also found in the second. When they have existed in the first, they generally continue in the second. The large crepitation of the second stage may mask them, but holding the breath will generally succeed in making them manifest to the mind.

When these bruits have not been present in the first stage, they occasionally show themselves in the second. But, on the whole, this sign is not very much increased either in intensity or in frequency, in the second stage of the disease.

Pericarditis occasionally complicates phthisis in its second stage, but less frequently than in the third. When it occurs, it is marked by the tumultuous impulse of the heart, the rapid succession of beats, and by the ordinary friction sound, formed when the disease occurs idiopathically or in consequence of rheumatism. The friction sound is rougher than that of the pleural friction, excepting when this last depends upon old, rough and hard exudations; and this is seldom heard in the region of the heart. The sound is divisible into two parts; one synchronous with the systole, and another with the diastole of the heart, or, in other words, one coinciding with the impulse or advance of the heart, and another coinciding with the retreat of that organ. The sound, as is well known, approaches that made in churning milk. It is heard pretty well over the entire seat of the heart, but it is loudest at the base or at the roots of the great arterial trunks. Pressure with the stethoscope rather augments it. Sometimes, together with the impression made upon the ear, another is made upon the hand, viz., one of fluctuation. The sound proves of short duration, lasting, for the most part, only some seven or ten days. Adhesions or effusion put a stop to it. Effusion being the cause of the cessation, when the liquid is absorbed the friction sound again recurs, but lasts only some days, when adhesions finally put a stop to it, now and for ever.

Endocardiac murmurs occasionally occur in the second stage of phthisis. Of course endocardial murmurs which existed before the accession of phthisis, will continue. I have observed that endocardial murmurs have been produced in some few cases of phthisis, for the first time, during the progress of the second stage. They depend, for the most part, upon inflammatory action of the lining membrane of the mitral valve. I have reason to think that they occasionally result from the now rapid circulation of the blood. Fibrinous deposits from the blood occasionally take place, and, attaching themselves around the auriculo-ventricular orifices, may give origin to these sounds.

The intensity of the heart's sounds, which I noticed as attendant upon the first stage of phthisis, is also an associate of the other signs of the second stage. The intensification is greater in the second than the first, as a general rule, but in some cases it is less in the second than it is in the first in other cases. The mechanism is the same in both stages. Sometimes the loudness of the cardiac sounds is lost in consequence of loud squashing liquid bruits.

CHAP. XXII.

SECOND STAGE — *continued.*

Percussion.— Dullness.— Wooden Dullness.— Absolute or Finger Dullness.— Natural Percussion. — Over-resonant Percussion.—Quasi cracked-pot Sound.

Percussion in the second stage of phthisis. — The dullness of the percussion sound in the second stage, though of great importance, is a less necessary element in the diagnosis of phthisis than in the first stage, so reliable is the humid crepitation which has been already described. In those examples of phthisis, in which a certain amount of loss of air character in the percussion sound has been observed, in the first stage, this is almost invariably increased in the second, and soon amounts to very decided dullness. The dullness of the second stage usually increases with the progress of the disease. In comparatively few examples of phthisis which have reached to softening, do we find the percussion note unaltered. Sometimes the reduction of air character is very slight, and is not to be made out without particular attention. Sometimes the dullness in such cases is not greater than the dullness we have in some healthy, stout, or narrow-chested, firmly-knit persons; and that the sound is not altogether healthy, is established only by percussing the opposite side, and eliciting there a clear and more continuing note. In many examples of phthisis the percussion sound is not more dull in the second stage than it is in other examples of the disease in the first. This is owing to two sets of facts: first, the presence of much consolidation, and absence of air in the cases which have arrived at the first stage; and second, the absence of unusual consolidation, or even of the ordinary amount of it, or the presence of vesicular lung in the immediate neighbourhood, the softening being confined to a small area, or the presence of emphysema in the adjoining structure in the examples of the disease in the second stage of the disease.

The dullness on percussion that is properly designated as very considerable or marked, is very common in the second stage of phthisis. When the chest is percussed, a dull sound is given out, as if the vibration of the walls of the cavity were short and rather strong. The sound too seems to include the sound of the finger percussed.

The sound emitted in numerous examples of phthisis in the second stage has been called wooden by some physicians, and among them by my much respected colleague Dr. Cotton. When describing, in his work on "Phthisis and the Stethoscope," this sound, he says, it is a jarring one; and this description corresponds well with the short, harsh, inharmonious noise produced. Dr. Cotton has exhibited to me specimens of this wooden sound at the hospital. To me it appears that such a designation of this sound as "marked dullness," or "very decided dullness," would answer better; for, as I have before shown, many varieties of sound may be procured from wood. It may be proper to remark, that if the term "wooden" is meant to apply to the sound obtained from a thick, short, solid, and not freely vibrating piece of wood, the designation would not be an incorrect or a vague one. When the chest is struck, and the very dull sound is emitted, it is obvious that the walls offer great resistance, and do not sink under the blow, and consequently do not rise, as is the case, to an inconsiderable extent it is true, when the elasticity of the walls is not destroyed by consolidation or the presence of liquid.

Absolute dullness is occasionally heard in the second stage of phthisis. This is a sound such as is produced when the finger is struck when held in the air. It seems when absolute dullness is produced, as if the chest contained no air whatever, or at least within reach of the stroke, and as if very little vibration were created in the walls of thorax or even in the finger that is struck. The remarkable absence of vibration of the walls of the chest, or, in other words, its almost absolute immobility, seems ever operative against the production of sound. The absolute dullness upon percussion is heard most frequently, chiefly at the base of the lung; at the apex it is very rarely heard, perhaps not above once in 100 examples. When it is heard at the apex, it is generally associated with very extensive consolidation and with great thickening of the pleura, and with preternatural adhesions at the apex. I have found it associated in one example of phthisis in which the liquid of empyema rose as high as the first rib. When the absolutely dull percussion sound is heard at the second stage of phthisis at the base of the lung, great consolidation with retraction of the chest is generally present. In some few examples I have had this sign associated with empyema. This form of dull percussion is much less frequently observed in the second stage of phthisis than in the third.

The percussion note of the chest in the second stage of phthisis is occasionally found perfectly normal, or at least not sensibly affected. The number of such cases is not great, but an instance of natural resonance is to be found from time to time, and it is therefore well to know that the value of humid crepitation is not rendered much less significant of phthisis by this coincidence. Upon inquiry it will be found, when this unaltered percussion sound is heard, that the tubercles are few in number, small in size, surrounded by vesicular or hypertrophied lung, or placed in the midst of a large mass of lung, or associated with a moderate amount of emphysema, characterised by sibilus or sonorous rhonchus, and very long and generally sibilant expiration. But when decided emphysema is present, it seldom serves merely to counterbalance the tendency to dullness caused by tubercle, but generally leads to excessive but not tympanitic resonance.

Excessive resonance occasionally occurs in the second stage of phthisis; but the physician in moderate practice may not meet with it for many years together, if at all. In the Hospital for Consumption it is occasionally heard. In such cases, the tubercle that is softening is small in amount, and little or no hepatization or pleural adhesion has taken place. It will generally be found that the disease of the patient presenting this physical sign has begun with emphysema; that this is of some years' duration; and that the tubercular deposition is a late complication. Patients in this compound condition are generally advanced in life. When the cough has been very violent, and much nervous dyspnœa has existed, emphysema is occasionally superadded to phthisis. I have seen this in young persons. I saw a child at the hospital a few days ago, in whose case emphysema was present, and was superadded to phthisis.

The increased resonance of phthisis in the second stage, and dependent upon vesicular hypertrophy or actual emphysema, is an unnaturally prolonged sound. In duration it exceeds the sound of the ordinary healthy chest. It partakes of the hollow sound of a box with rather thin walls, filled with materials such as feathers, and it conveys to the mind the idea, which is a correct one, that the solids percussed vibrate more freely than usual, as well as for a longer period than is usual.

Bruit de pot fêlé sound, or, to employ English words, cracked-pot sound, has, in the opinion of some auscultators, been heard in some instances of phthisis which had attained to the second stage only. There is no doubt that a sound resembling, and that may be mistaken for, this very characteristic sign, is occasionally heard at this period of phthisis, as well as under other conditions, such as the first stage, partial hepatization, great elasticity of the walls of the chest in young children subjected to strong and rather sudden percussion. But this is not the true or developed cracked-pot sound as generally understood, or that which we hear in the third stage of phthisis. The quasi cracked-pot sound of youth, of hepatization, and occasionally of pleural effusion reaching to the apex of the chest, is marked by a loud short percussion noise, and with a sound of sudden expulsion of air, either from the lung itself, or from bronchial tubes. It differs from the ordinary percussion, by having superadded an air expulsion sound. This sign is destitute of the marked metal clink of the true sign of the third stage. The quasi bruit de pot fêlé sound of phthisis in the second stage, is of little value as a diagnostic sign of the disease. I am inclined to place its value low. Nevertheless it is proper to notice it here.

The true bruit de pot fêlé sound is a compound one: it is composed of the ordinary dull sound of percussion, and of the sounds which arise from the forcible and somewhat resisted expulsion of air from a cavity having thin smooth walls capable of imparting a metallic tone. The sounds of expulsion are metallic, or clinking, or short jingling, from the structure of the walls of the cavity, and they are jarring and inharmonious, because the vibrations are abruptly arrested by the loss of air essential to their continuance, and by the presence of adhesions.

CHAP. XXIII.

SECOND STAGE — *continued.*

Form of the Chest. — Movements of the Chest. — Decrease on diseased, and Increase on healthy Side. — Dimensions of Chest. — Vital Capacity.

The form of the thorax in the second stage of phthisis more frequently presents abnormal deviations than the first stage. Abnormal alterations in the configuration of the chest are found in the second stage of many examples of phthisis, in which, during the first stage, the form remained nearly natural. In many cases in the second stage, deviations from the natural configuration are found for the first time, and add to the signs which guide us in diagnosis. In those examples of phthisis, in which deviations from the natural form were observed in the first stage, we notice that these abnormal alterations not only continue, but become decidedly more marked, and continue to become aggravated with the progress of the second stage. The extent of the deviations in the second stage, as in the first, corresponds with the extent of the disease.

The softening process may be very complete, and yet be confined to a small area. In such cases the extent of the abnormal deviation will not be great quoad space.

All the forms of deviation in the shape of the chest described as occasionally occurring in the first stage of phthisis, are found in the second. The flattening, the rapid receding backwards of the ribs, the declension of the shoulder due to a closer approximation of the upper ribs, are all found in the second stage, and as a general rule, are greatly more marked than in the first stage, though less so than in the third.

When the process of softening is arrested, the morbid deviations from the natural configuration of the chest, are for the most part suspended, provided that the softening be not converted into, or exchanged for, large cavities. The deviations which occur in the second stage are the following: — double flattening, or flattening of both sides of the chest under the clavicles, single flattening or flattening under one clavicle, undue angularity of one or both sides at the sterno-costo-cartilage and costo-cartilage articulations from unusual recession of the ribs, &c.

Besides the deviations from the configuration of the chest just noticed, we observe that the contraction of the side is very common. This is the result of hepatization, and of the destruction of the vesicular tissue by the pressure of tubercle. The increased dimensions of the side, temporary it is true, the greater roundness and the greater fullness and the extent of the intercostal spaces due to the presence of serous or sero-purulent fluid, the result of pleuritic inflammation, are occasionally observed in the second stage; more frequently in this stage than in the first, but much less often than in the third. The dorsal vertebræ form an unevenly rounded line, the convexity being directed backwards and upwards, and the upper part of the line being unduly inclined forward, imparting the appearance of stooping forward, so common in phthisis. This bending forward and the rounded back is more frequent in the later stages of phthisis, and to this form and kind of thorax has been applied the term "consumptive back," but perhaps with some degree of impropriety, as it is very commonly observed in other diseases signalized by long continued debility, and also in mere old age.

To dilate further on the deviations of the thorax in the second stage of phthisis, appears unnecessary, as they have already received considerable notice when the first stage was treated of. I would simply say that though deviations are exceedingly common, it is not by any means a rare thing for the physician to find the chest, at this period of the disease, in its perfectly healthy form, so that the absence of deviation in shape cannot invalidate the testimony, quoad phthisis, of other signs, such as humid crepitation and local dull percussion. Nor can the presence of flattening, even under one clavicle, in the absence of more precise signs, be relied upon more than to necessitate further watching.

The movements of the thorax in the second stage of phthisis are much more affected than in the first, but less than in the third stage. When deficiency of motion has been noted in the first stage, this sign is usually increased and more readily recognised in the second, particularly if the softening process be somewhat protracted, and if it be accompanied with much adjacent lymph exudation. The increase of this sign, like the increase of the morbid alteration of shape, is frequently not very marked, for this simple reason, that the process of softening and breaking down, and expulsion of tubercle is frequently of very short duration and speedy of accomplishment, and this soon terminates in the formation of the third stage. In many examples of softening, or of the second stage of phthisis, a deficiency of motion is made out, although, while these cases were in the first stage, no such sign was observed.

In nearly all examples of softening, a deficiency of motion under the clavicle and over the seat of the disease, is readily made out both by the eye and by the hand placed upon the part. Yet it is to be constantly borne in mind, that in some not very rare examples of phthisis arrived at the second stage, the motion of the chest is, as far as our tests avail, perfectly normal. The eye, the hand, and the different stethometers and measures give no certain indications of unhealthy deficiency in the extent of movement. We must therefore not conclude that softening of tubercle is not progressing, simply because we find no deficiency of motion. It is more frequently in examples of acute phthisis than in chronic that we see full normal motion of the ribs.

We frequently see very considerable deficiency of motion in examples of phthisis which had attained the second stage, and which, now improving, present only the signs of the first stage of the disease. These cases are such as have had softening and expulsion followed by very small cavernules closed or closing.

The deficiency of motion under consideration is found to embrace more or less of the space from the lower edge of the clavicle to the third rib inclusive. The deficiency begins at the upper part of this space and gradually descends. It is chiefly in the more extensive examples of softening that the deficiency is observed as low as the third rib. When pneumonia has occurred in the softening stage, to a great extent in this stage, the loss of motion is remarked to be great, and to comprise the lateral expansion of the ribs. The same is observed in examples of that condensation of the lung that occurs after the absorption of extensive pleuritic effusion.

The deficiency of lateral expansion is very common in the second stage of phthisis. It is readily detected by the eye, but it is more sensibly perceived by placing the palms of the two hands respectively over the two sides of the chest at the same moment. While the inspiratory act will lift the hand placed upon the healthy side, the hand placed upon the unhealthy part is left comparatively motionless. This deficiency is generally dependent upon destruction of the vesicular structure by pneumonia, by congestion, or by tubercle. The semi-diameter is almost invariably reduced. The deficiency of motion is occasionally due to effusion within the pleura. When this is the case the semi-diameter is increased.

The dimensions of the chest in the second stage of phthisis are very generally affected in an abnormal manner. Comparatively few examples of phthisis in this stage are found in which the dimensions remain unaltered. As the second stage progresses, the alterations become more manifest. Examples of softening, that is, extensive, have the abnormal alterations in greater proportional number and in a more marked form than contrary cases. The morbid alteration in the dimensions, which we observe in the first stage, increase in the second.

On the diseased side of the chest the alterations are those of reduction, and this reduction is most conspicuous in the antero-posterior diameter of the chest below the clavicle, best measured by the callipers, and in the semi-circumference of the chest below the nipple, measured by a tape measure passed from the sternum round the diseased side, and reaching to the spine. The amount of reduction in the superior antero-posterior diameter is moderate in respect to the scale of inches, but very significant of mischief.

The diminution of the dimension of the diseased side from the sternum to the spine, in respect of the scale of inches is much greater, and often reaches as much as one inch or one and a half inches. A large proportion of the patients in the second stage, who have come under my care in the hospital, have been the subjects of a diminution of the semi-circumference of the chest.

While the diseased side in phthisis is obviously becoming smaller, and offering smaller dimensions, the opposite side tends to an increase. There is reason to believe that the semi-circumference of the healthy side of the chest, at its middle and base, increases to the extent of about half an inch. This is due to increase of the size of the vesicles of the lung, now in a compensating manner receiving more than the normal amount of air, and being constantly distended to a more than usual extent.

The vital capacity of patients in the second stage of phthisis is very materially reduced, whether we compare it with the capacity in health or in the first stage of the same disease. The difference between the vital capacity of the first and second stages is considerably less than between the vital capacity of health and the first stage of phthisis, as determined by Dr. Hutchinson. The following table is constructed from Dr.

Hutchinson's data, as they appear in Dr. Tanner's "Clinical Medicine," and shows the capacities of phthisis in the second stage and in health, stature being included.

Height.					Capacity in Second Stage of Phthisis.	Capacity in Health.
Ft.	In.		Ft.	In.	Cubic In.	Cubic In.
5	0	to	5	1	99	174
5	1	to	5	2	102	182
5	2	to	5	3	108	190
5	3	to	5	4	113	198
5	4	to	5	5	117	206
5	5	to	5	6	122	214
5	6	to	5	7	127	222
5	7	to	5	8	131	230
5	8	to	5	9	136	238
5	9	to	5	10	140	246
5	10	to	5	11	145	254
5	11	to	6	0	149	262

As determined by my own observations obtained from the examination of my patients in the hospital, I find the vital capacity of patients in the second stage of phthisis is not very different from that given by Dr. Hutchinson. The following six observations, made with care upon patients with decided softening and seriously ill, may be interesting:

WEIGHT. Ft. In.	CAPACITY. Cubic In.	WEIGHT. Ft. In.	CAPACITY. Cubic In.
5 5	130	5 8 (H. F.)	150
5 6	140	5 8 (A. B.)	150
5 7	120	5 9	130

In a diagnostic point of view, the vital capacity test in the second stage of phthisis is of no practical value whatever; yet it is interesting to know what amount of air may be expired at this period of the complaint, and possibly it may prove hereafter of some practical utility.

CHAP. XXIV.

SECOND STAGE — *continued.*

Throat Signs. — Constriction Sounds.— Moist Crackle.—The Voice.—Cough.—Glottis. — Epiglottis. — Pharynx. — Uvula. — Gums. — Tongue. — Nares: Snuffing-like Sound.

THE physical signs of the throat, as a general rule, are more marked in the second stage of phthisis than in the first. The morbid alterations of the voice attain to a greater height.

Examples of phthisis, in which no physical throat signs were observable in the first stage, become marked with them in the second. For the most part, these throat signs, whether taking their origin in the first or in the second stage, continue to increase, except in those examples of the disease in which a quasi cure or a quiescent state takes place. It may be affirmed as a general rule, that voice alterations in the second stage of phthisis are seldom removed. The noisy and constrictive respiration through the larynx and trachea and glottis, is more frequently found in the second than in the first stage, and it is more marked, though there are exceptions to this rule. In some cases so great is the roughness, or sawing constrictive sound, in the first stage, as greatly to exceed the same sign in other examples of the disease in the second.

The hemming noise or expiratory glottis and larynx bruit, is very frequent in the second stage of the disease.

Moist crackles in the throat, i. e. in the trachea, in the larynx, and at the glottis, are very common in examples of this disease at the second stage. They are single, or nearly so, but several successive cracks may be heard during one inspiration or one expiration. They are more frequent during expiration than during inspiration. Sometimes only one is heard during an expiratory act. The sound proceeds from the mouth, and is conveyed to the ear of the physician through the air. The sounds are more fully heard when the stethoscope is applied to the throat. To auscultate the throat, the flexible stethoscope, such as Camman's or my own, with ear pieces that enter the ear, answer best, for simple contact with the throat without pressure is sufficient to give a distinct auditory impression.

The voice, in the second stage, when the disease is unequivocally declared, is almost uniformly found to be morbidly altered. The modifications of the voice are the same as are perceived in the first stage. The more frequent alterations are a reduction in force, the voice being then simply weak. It is very frequently reduced to a mere whisper. A rough and dry abrupt noise is very common. A loss of pitch, when the voice is said to be thick, is of very frequent occurrence, and is generally the precursor of more grave vocal disorders. An almost inarticulate sound, exceedingly abrupt and disagreeable, is sometimes the only remnant of the voice, but this is much more rare than in the third stage of the disease.

In almost all cases of vocal disorder, there are discovered some occasional remissions and exacerbations, and the alteration of the voice seldom continues to be uniform for many days together. In many examples the voice will change several times materially in the course of an hour.

The constrictive voice, which is occasionally heard in the first stage of phthisis, is of pretty frequent occurrence in the second, but less so than in the third. It depends upon chronic inflammation of the glottis, œdema of the glottis, or ulceration of that part, or, as is not uncommonly the case in the latter periods of the second stage, upon destructive ulceration of the mucous membrane of the larynx, involving the removal of the vocal chords and necrosis of the cricoid arytenoid and thyroid cartilages of the larynx.

The cough in the second stage of phthisis is very troublesome and very frequent; it invariably presses in the morning, and at that time particularly it is accompanied with the expectoration of opaque muco-purulent sputum, yellow or green in colour, and frequently mixed or tinged or streaked with blood. The sound is occasionally that of constriction at the glottis, but this is much more rare than in the first stage of phthisis. The cough in the second stage sounds as if the larynx and trachea were well lubricated with thickish liquid, and as if the air, in the act of being expelled, passed in part through it, which is no doubt the case. The cough is less short than in the first stage, and usually consists of three or four distinct rather slow and loud loose partial expirations. Occasionally these three or four partial expirations are repeated again and again, but it is rather rare for the patient to cough above half a minute at a time, and he seldom evinces lividity of face or very great distress.

The glottis when felt by the finger, is found in this stage to be frequently in an abnormal physical state. Most frequently the abnormal condition is one of thickening. The rima glottidis is full, and more than usually rounded. This is the case in chronic or sub-acute inflammation. Occasionally the rima is large and unduly pulpy; this state is found when the parts are œdematous, in which condition the voice is permanently reduced to a quasi whispering. It is seldom that the rima is irregular from the presence of ulceration; but this condition, though almost peculiar to the third stage, and the advanced periods of it, is occasionally found in the second.

The epiglottis at its edges and its under surface, is frequently found to be irregular, from the presence of ulcerations, which tend to become deep at the period of the disease under our consideration. This ulcerated state may be felt by the finger. The epiglottis is very frequently the subject of active arterial injection, and may be occasionally seen with the unassisted eye to be highly injected and reddened. I have seen the epiglottis in not a few examples of phthisis at this period of the disease in the state described, and much resembling a small scarlet geranium petal.

The posterior wall of the pharynx in a large proportion of examples of phthisis in the second stage is morbidly affected. The colour is generally deepened, and more than the usual number of vessels are seen ramifying upon it. The vessels are injected, frequently stand out in relief, and are tortuous to such a degree as to entitle them to be called varicose.

The surface is unduly roughened, the fine smooth surface of health being lost. Numerous elevated spots, of a red or reddish-purple colour, stud the posterior wall. These spots vary from the size of a divided coriander seed to that of a split pea. They are masses of engorged and hypertrophied mucous follicles. Ulcerations seldom take place at these spots in the second stage of phthisis, but in the third they are not uncommon. Aphthæ are seldom seen at this early period of the disease. When the pharynx and the larynx are in a state of chronic inflammation, difficulty is experienced in the act of swallowing. The act is often painful.

The uvula is frequently found to be elongated and œdematous or clubbed at its free extremity. It frequently rests upon the tongue; numerous small blood-vessels are seen upon it, swollen, and often of a dark venous colour. The tonsils are occasionally swollen and unduly vascular, and of a rather purplish colour.

The gums are very frequently the seat of hyperæmia and of congestion to a very small extent from the margin. It is found generally on both gums, the upper and lower, most, however, on the lower. The depth of the congestion surface may be very small, amounting to not more than the breadth of large bristle; but I have seen it fully the breadth of half a line. The congested part is tumid and swollen, and often emits blood, particularly on eating, and on brushing the teeth. The blood which is found in the mouth of patients in the morning in the second stage of phthisis, and also in the third, frequently proceeds from this source. The amount of blood is seldom great, not more than a few drops, and it gives a particularly saline impression to the tongue. When the teeth are covered with tartar where they are embraced by the gums, the red border is more intense. Unlike the blue border of the gums in lead contamination, which is not observed where teeth are wanting, the red fringe or border in phthisis is generally unbroken, notwithstanding that some of the teeth may be lost. The red border holds on the interior as well as upon the exterior surface of the gums, though to a less extent. In examining the physical condition of the mouth, the glottis, epiglottis, pharynx, and tonsils, it is well to illuminate the parts freely. Simple illumination will suffice to observe all the parts named, except the glottis. In some persons the epiglottis may be seen with the unaided eye. To see these parts it is generally necessary to employ a speculum or mirror, introduced into the mouth, so as to have an image of them reflected upon the retina of the physician. Avery's speculum oris answers well. The laryngoscope of Czermack is exceedingly useful in the exploration of the physical state of the mouth and pharynx; but of this and the other instruments available in physical exploration, I shall treat at the conclusion of this work.

The tongue seldom presents appearances in the second stage of phthisis, which are not commonly observed in many other diseases, and when they do occur they are of no avail in diagnosis, and require no special treatment. They are, therefore, unworthy of detailed notice here.

Occasionally the tongue is coated with a white or yellowish fur, particularly near the root. I have remarked that it is not uniformly distributed, but often prevails more on one side than on the other. It occasionally separates in parts, leaving rather clean-looking spots.

The tip of the tongue, in a few cases, is reddish, and has its papillæ red and elevated, giving a file-like appearance.

Occasionally, small rather deep ulcerations are seen upon the sides of the tongue, chiefly where that organ comes in contact with the sharp points or edges of the teeth.

THE NARES IN THE SECOND STAGE OF PHTHISIS. — These canals are occasionally the seat of physical alteration in the second stage of the disease. The mucous membrane is found to be injected and deeper in colour than usual. The whole canal is, in such cases, generally the seat of increased secretion. This is often more liquid than natural, generally greenish or yellow in colour. It is occasionally tinged red with blood. The liquid secretion coming down the nostrils becomes thickened into crusts upon the outlets, if allowed to remain sufficiently long to dry, and these crusts frequently give rise to abrasions and even to ulcerated spots. Occasionally a discharge of this mucus falls into the pharynx, and if of an irritant character, produces hyperæmia, &c., in that part. Occasionally the voice is altered, acquiring a nasal twang, from the presence of a thickened and congested membrane, and from mucus lodging upon it and interfering with the due transmission of the laryngeal and oral voice. This nasal twang is sometimes nearly permanent, sometimes it comes and goes repeatedly in the course of a few days, and may not last each time more than half an hour. It may suddenly cease by the expulsion of mucus, either by blowing the nose or by a coarse inspiratory effort when the mouth is closed.

When the nares are loaded and narrowed with mucus, the coarse inspiratory effort just referred to is frequently made. A prolonged inspiration is effected, the mouth being closed, the nostrils are narrowed at their facial extremity, a smart current of air is drawn from without along the nasal canals; the whole nasal apparatus is thrown into prolonged vibration, and a peculiarly coarse and highly disagreeable noise is made. This is frequently repeated. A coarse sucking-like or snuffing sound is produced. Ulcerations of the mucous membrane of the nasal canals are sometimes induced, but this is much more a feature of the third than of the second stage of phthisis.

CHAP. XXV.

SECOND STAGE—*continued.*

Concluding Remarks. — Duration. — Grouping of Signs. — Exchange for Signs of Third Stage: for Signs of Fourth Stage.

THE duration of the signs of the second stage of phthisis, is upon the whole greatly shorter than the first and third stages. In some cases it is even shorter than the duration of the signs of many examples of the disease in the fourth siage. The signs last generally some weeks. They seldom endure longer in one place than two months, being then succeeded by the signs of cavities of some considerable size, i. e. of the third stage. In active cases, in young adults, and in cases marked by much inflammatory action, the softening process may be concluded in a few days, and the parts being expectorated, cavities with their peculiar signs are formed.

The grouping of the signs of the second stage is less varied than in the first. The moist crepitation is always a leading and prominent sign. There may, or may not, be dullness of the percussion sound, there may, or may not, be deficiency of motion and deviations from the natural shape of the thorax, but we have always the one grand sign, viz., moist crepitation.

The course of the signs of the second stage of phthisis is frequently cut short by death, particularly in the acute form of the disease, and in young subjects of weakly and irritable constitution.

The second stage signs must in every case of phthisis be present before the commencement of the third stage. But I am not sure that the second stage may not pass directly into the fourth or perforation stage without the occurrence of the third. If this event ever take place, that is, if perforation may occur in the course of softening, then the signs of the second stage may be exchanged at once for those of perforation or pneumothorax. Of this fact I am certain, that I lately discovered the signs of perforation in a gentleman who only some days before afforded to careful examination the humid crepitation of the second stage only, and who, moreover, had been, as his friends stated, in perfect health some weeks before, and had just accomplished a pedestrian excursion upon the Pyrenees.

The signs of the second stage when succeeded by those of the third, are by no means lost as a whole. The chief difference in respect of the second stage signs, is the loss of the moist crepitation sound at the spot which has become excavated. The moist crepitation may even yet continue, and appear around the seat of the cavity at another part of the diseased side, as the middle or the base, or it may be now heard upon the opposite side of the chest.

CHAP. XXVI.

THIRD STAGE.

Decisive Nature of Signs.—Grouping of Signs.—Cavernous respiration Sounds: little audible: blowing, gentle, and harsh.—"Sawing" cavern Sounds.—Creaking Sounds.—Amphoric blowing.—Cavernous Rhonchus.—Cavern crackling.—Metallic Tinkle.—Musical cavern Sounds.—Liquid cavernous Sounds and their Seats.—Cough cavern Sounds.—Table.

The physical signs of the chest, throat and oro-nasal passages in the third stage of phthisis or that of excavation, are those which are generally presented by the sufferer from phthisis, to the consultant physician, when he first offers himself for examination, when he desires to know whether his lungs are "touched," and demands "a cure for his cough." A large proportion of the patients really suffering from phthisis, who have presented themselves before me for advice, both at my private house and at the Hospital for Consumption, have been found to be in the third stage of the disease, and to afford those physical signs which are perfectly decisive of the nature and extent of the malady. Not less than one in two of phthisical patients presenting themselves have been found the subjects of signs which have permitted no doubt whatever of the advanced condition of the malady; and this proportion has held nearly as well with those patients who were not materially wasted, and who still exhibited in no small degree the usual accepted signs of good health, such as embonpoint, florid complexion and muscular activity, as with the thin and emaciated subjects. I may safely say that of phthisical persons consulting me in private, three fourths have cavities.

The vast importance of the physical signs, of the ability to detect them or recognise them, and their value as exponents of morbid structure and morbid conditions within the chest, must appear manifest from these facts. The symptoms of the patient, if of less value than the signs in the first stage of phthisis, are, at least as far as diagnosis is concerned in the third stage, of scarcely any value whatever compared with physical evidence. The inspection of the chest, the percussion and auscultation occupying, it may be not more than three minutes, are perfectly decisive. As far as the question of the nature of the disease, its stage, and perhaps even the prospects of the patient, are concerned, the long narrative of friends is, in the last degree, tedious and unprofitable compared with the information the skilful adept in physical diagnosis obtains from his physical examination, it may be of not more than two minutes' duration. So much more valuable are two minutes spent in actual examination, than half an hour given to the history of the case in the third stage of phthisis, that whenever I find a private patient presenting a reasonable probability of his disease having arrived at a period beyond the first stage, I invariably beg that I may be permitted to examine the chest first. After this I am willing to listen to the history of the case. When once I have examined the chest, &c., and discovered the signs of the third stage, I devote no time to evidence that can only lead to suspicion. There is now no occasion to weigh probabilities as to the nature of the disease, and time may be more profitably expended, for the patient, in giving directions for the mitigation of his malady, the relief of his symptoms, and for increasing by ever so little the moderate chances of his recovery. Having examined the patient, and found those physical signs pregnant with his fate, the physician can then interpret with intelligence, or, as with the key of the scholar, the narrative of his patient, and knowing the value of his life, may direct with profit and prudence, brief as it is likely to be, how it shall be expended to the greatest advantage.

It may be permitted to me to remark here upon the extraordinary precision of the knowledge the expert physician obtains from physical signs. The knowledge they impart as to the nature of the disease of the patient is in itself marvellous, and the impression made upon the mind of the physician conveys an extraordinary consciousness of the power of knowledge and education. He feels that the thick and vague atmosphere of conjecture is dissipated, and a clear well defined landscape is, as it were, presented to his eye. The opprobrium of doubt and uncertainty, which has been so freely attached to medical science, he feels is, now at least, altogether misplaced and totally unjust. He may compare with the surgeon in his happiest moments of precision, even as when, in a case of suspected stone in the bladder, he realises the fact by the clink and impulse gained by the introduction of the sound. The physician dealing with phthisis in its third stage knows, by the evidence of physical signs, as certainly the condition of the lungs, as in some obscure affections of females, the accoucheur, by means of tactual examination, finds the case to be one of natural pregnancy. In the one case a cavity has been physically discovered, in the other a child has been felt.

In describing the physical signs of the third stage of the thorax in pulmonary consumption, I shall take them in the order of their prominence and of their importance; but before proceeding to a detailed account of each sign, it may be well to describe the general results of examination. In a very large proportion of the examples of phthisis in its third stage which have come before me, and they must have amounted to some thousands, I have noted the following conditions of the chest. We observe that the chest below the clavicle is decidedly flattened or depressed into a shallow hollow The heart's impulse is seen and felt at the second interspace, on the left side of the chest, if the disease be located there; on the right side, if that side be the one affected. The interspace is constantly moving backward and forward. If the single stethoscope be applied to the diseased part, we notice that no vesicular fine divided sound, such as of air blown through a hair sieve, is to be heard as in health, and in its place the noise of air, as if moving in large unopposing chambers, is made out. The sounds of air moving in these chambers vary much; sometimes they are blowing and sawing, as if the air were opposed in its entrance into the chambers and in its exit, by the bronchial tube or the mouth of the cavity. Frequently a moist sound is heard, from the air passing into the cavity, forming a bubble with the liquid which it meets at its point of passage into the cavity. Dry cavernous quasi-creaking sounds are occasionally heard in the more passive and chronic examples of the disease. If the patient speak, the voice seems to be whiffed from a cavity immediately under the stethoscope into the ear of the auscultator. This takes place when, as in most cases, there exists a free communication between the cavity and the larynx, and when the pulmonary structure between the cavity and the walls of the chest under the stethoscope is reduced to a rather thin partition. Sometimes the voice is very strong, less clearly articulated and distinct, but shaking in an undue manner the stethoscope, and even the auscultator's head. This occurs when the cavity is rather small, has full bronchial communication, and is covered with some thickness of pulmonary structure more or less devesiculated. The percussion note is dull in most instances, short in vibration area and in duration, and contrasts strongly with the resonance of any healthy part of the chest. The heart's sounds are far more loud at the second interspace where the impulse is seen than at the apex, i. e. at the fifth interspace, the normal point of greatest intensity.

In some examples of phthisis in the third stage, forming a small group of cases, the flattening, the dullness, and the distinct chamber dry sounds are not to be found, or, at least in the decided form, obtained in the former and much larger group of cases. The chief signs are moist cavernulous, petty gurgling sounds, and a somewhat strongly vibrating voice. There is often no depression, and the alteration of the percussion sound may be very little marked. These are acute cases, accompanied with much secretion, having small cavities frequently connected, occasionally descending to the base, and of very recent formation. Examples so marked are generally found in children and young adults, and they prevail much amongst irritable, strumous persons. Very frequently these cases terminate in death, ere large caverns can be formed; but a few examples continue long enough, and become signalized by large cavern moist sounds, or gurgling and cavernous pectoriloquy. A very few cases continue longer, and lose much of the excessive secretion, and with it the moist sounds, now to be replaced by the large dry air chamber sounds noted in the first group of cases.

A small group of cases is found presenting very different characters. The percussion note is tympanitic all below the clavicle. Amphoric bottle-neck blowing or chink-blowing is heard chiefly at the superior regions, but it may be throughout the entire side; a few moist crepitations may be heard above the clavicle; no vesicular respiration sound is heard throughout the side; the voice sounds as it would in a pitcher. These are examples of phthisis in the third stages, complicated with, and rendered very urgent by, perforation of the pleura, and by pleural respiration, instead of pulmonary respiration. This is a very remarkable group of cases. The examples of which it is composed have generally been a long time in the third stage. Their physical peculiarities depend upon an organic change to which all third-class cases constantly tend. Their signs are highly striking, and differ greatly from those of the third stage. The subjects of this condition tend to speedy death. For these and other reasons I have determined to treat this group of cases as examples of phthisis in a new or fourth stage of the disease. In doing this I am diverging from the path trodden by other physicians, but I believe the advantages of this step will counterbalance its inconveniencies.

Another group of cases small in number comes under our notice. They are signalized by cavernous gurgling or respiratory and vocal sounds at the apex, less extensive than ordinary, and by absolutely dull percussion of the side with decubitus on the affected side, absence of respiration, and occasionally with trembling goat-like voice. These are cases of phthisis in the third stage, complicated with empyema on the affected side.

These are the well-defined and distinct groups of cases which present themselves to the physician. Other groups may be said to exist, but they are less distinct than those described, and are rather varieties of the above groups than separate ones. Thus we occasionally see a case of phthisis in the third stage, with all the signs of the first group, excepting the dull percussion. The dullness may not be present on account of emphysema, or of the great extent of the cavity filled with air, or of the absence of hard or firm binding exudation, nevertheless, it would be an unnecessary multiplication of groups to form one for such exceptional conditions, these being of little importance under the circumstances, or in a question of general arrangement.

CAVERNOUS RESPIRATION SOUNDS IN THE THIRD STAGE OF PHTHISIS.—When one ear of the physician is applied over the seat of a considerable or large cavity in the lungs, whether immediately or by means of a sound conducting instrument, certain sounds are heard which never exist in health, and fortunately they possess such distinctive characters, that, though varying much in themselves, they cannot be mistaken except in very rare cases, for the sounds of the lung in other morbid conditions. In nearly every example of phthisis in the third stage, which is one of considerable-sized cavities, certain sounds are heard during respiration, during the admission into, and expulsion of air from the chest, and indeed from the cavity itself. These sounds tell their history the moment they are heard. They are the products of air passing into, and out of, chambers, more or less moist, with more or less opposition from the cavities, their tubes and their contents; and the mind of the auscultator perceives this the moment they are heard. The mind is conscious that the sounds differ *in toto* from those of air passing into and out of, vesicular lung.

In almost all examples of cavernous sounds, we discover a deficiency of fullness and duration. There may be present loud gurgling, creaking or popping, yet there is absent that fullness and prolongation which we mark at the seat of healthy lung. Even when "sawing" sounds are heard, the duration and fullness, so to speak, are remarkably deficient. This reduction of the duration and fullness of sound in cavities compared with the sounds of healthy lung is ascertained by successive trials of the unhealthy and the healthy parts with the aid of the single stethoscope, or simply by the application of one ear. But to realise the deficiency in a much more marked degree, it is simply necessary to apply the two ears at once to the unhealthy and the healthy parts of the chest respectively, which is virtually done by employing my differential stethoscope. While a full prolonged noise of vesicular respiration is heard by means of one ear, no sound whatever is heard by means of the other, unless strong adventitious sounds are proceeding from the cavity, such as gurgling or "sawing" or creaking, and these sounds are always greatly less full than the sounds heard by means of the other ear connected with, or applied, by means of the stethoscope to, the healthy lung. The sounds in the two ears respectively, measured by the sensations, the auscultator's experiences, have this comparative duration and fullness denoted by these diagrams.

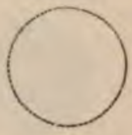
Healthy side.

Cavern side.

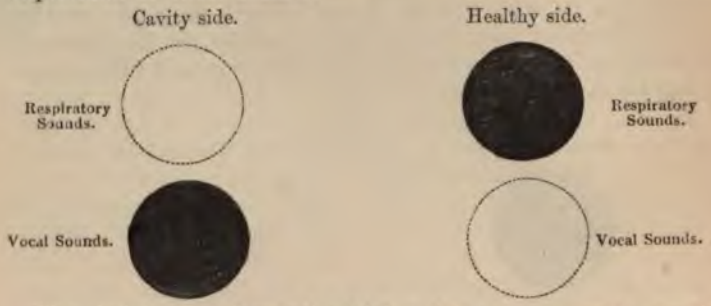
When, as very frequently happens, a cavern is comparatively silent, in consequence of active arterial action and over-secretion having ceased, and from the absence of much friction between the air and the walls and openings of the cavity, little cavern sound only is heard by the single ear, employed either direct or by the medium of the stethoscope. But when the two ears are applied at the same moment, to the unhealthy and a healthy part respectively, by means of the differential stethoscope, no sensation of sound whatever is obtained through the ear connected with the cavern. A noise, viz., the sound of the cavern, is of course conducted into the ear; but in the presence of the full and prolonged impression made upon the other ear, it fails to produce the very least sensation. The sounds of the cavern and the sounds of the healthy lung, as thus tested by the sensations which they produce, are respectively *nil* and full-prolonged. The following diagrams represent the sounds as expressed or measured by their respective sensations The dotted circle is *nil*, and appertains to the cavity; the black circle represents full sound, and appertains to the healthy lung.

Healthy part.

Cavern.



The sensorial absence of respiration sound at the cavity, is, perhaps, rendered more remarkable, by desiring the patient to speak. The order of things is now reversed. The cavity part usually rings with the voice, while the healthy part is silent. The acoustic circles may serve to convey a ready impression of these results.



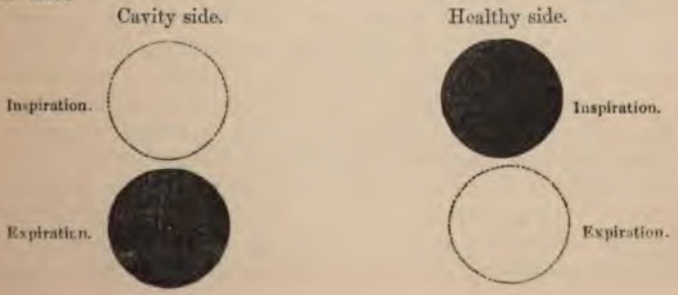
The deficiency of sound which exists in caverns is much more distinctly made out by the differential stethoscope than by any other means, and the employment of this instrument, even for one moment, will suffice to impart a consciousness of deficiency that is, even on the first trial, very striking. This deficiency is always most useful in marking and proving the presence of an abnormal state at one or other part, far most frequently at the part which fails to give a sensation.

In some few examples of cavities attended with very loud sounds, such as loud sawing and loud blowing, and when the respiratory sounds of the healthy side have been rather feeble, I have found the morbid sounds to eclipse the healthy ones. Instead of silence being observed, at the diseased side, silence is maintained at the healthy. The figures represent these acoustic phenomena.

Though the results of the employment of the differential stethoscope have been thus rather largely dwelt upon, no fear is entertained that the reader, when he has himself tested the instrument upon patients in the third stage of phthisis, and compared impartially its testimony with that of the single stethoscope, will hesitate to admit that the attention demanded for it has not been injudicious or unprofitable.

DRY CAVERNOUS SOUNDS.—One of the most common forms of cavernous respiration sound which presents itself to the physician when the patient first seeks his advice, is one of a very noiseless character. It consists of the bruit such as air causes when gently admitted in a cuplike chamber, such as a small elastic gum bottle provided with a large orifice. The entrance of air is gentle during the inspiratory act, and is successfully imitated in the case of the gum elastic bottle or bag, by gently opening up the hand which holds it in a compressed shape. The sound is simply a gentle admission sound. A full and rapid inspiration will, by causing a more rapid entrance of air, succeed in producing more noise, again to be imitated by *rapidly* removing the compressing hand from the gum elastic bottle. This quiet chamber admission sound is generally followed by a quiet chamber exit sound. Sometimes the exit makes more noise than the admission; this results from the construction of the bronchial entrance: frequently it is valvular, offering little or no resistance to admission, but offering some impediment to expulsion. The solid edge presented to the air that is being expired, may be more calculated to produce friction and noise than the surface operated upon by the entering air. A noisy expiration from a cavity is a common sequel to a noiseless inspiration. In some examples of dry cavities, the expiration becomes very noisy, and when the differential instrument is employed at the same time over the cavity and over a healthy portion of lung, an auditory sensation is obtained in one ear, and silence holds in the other. The sensation of sound is procured from the ear connected with the cavity, and silence holds with the ear connected with the healthy lung. If silence has held in such a case in or through the ear connected with the cavity during inspiration, we have then a sensation of sound during expiration, and an absence of sound, or silence, during inspiration in the same ear; while the order is reversed with respect to the other ear, which has silence during inspiration and heard sound during expiration.

The following symbols illustrate these auditory phenomena. The black circles indicate sound, the dotted circles indicate silence.



Of this series of auditory phenomena I have at this moment a very fine example in the hospital, in a patient in the third stage of phthisis.

The deficient quiet cavernous sound of phthisis is difficult to describe. It possesses very little of the positive in character. It amounts by no means to blowing, unless the patient quickly and somewhat abruptly inspires. When he makes a forcible imspiration, the term "blowing" may then be properly applied to it. The sound, from its want of loudness, and from the absence of any positive quality, might almost justify one in describing it as a noiseless respiration sound. Absurd as such a description may appear, it conveys a better idea of the sound than any other I can give; for when contrasted with the full, loud, opposed vesicular breathing sound of healthy lung, particularly when heard through the opposite ear, by means of my stethoscope, it certainly is comparatively noiseless; at least, that is the notion that occurs to my mind.

That the sound of respiration through a cavity should be comparatively noiseless appears easy of explanation. In vesicular lung, the current of air inhaled meets with obstacles in every terminal bronchus, and in every minute air cell. These parts resist motion—the motion of the air—and motion resisted is an essential element in the origination of sound. When cavities exist, these obstacles are gone, and sound, if now heard, is due to other sources of resistance, found chiefly in the walls of the cavity, in the entrance into the cavity, and in the liquid in front of the entering column of air, or to the formation and rupture of bubbles, the combination of air and liquid.

Blowing cavernous sounds.—The respiratory sounds of a large proportion of cases of phthisis presenting good-sized cavities, is decidedly of a blowing character. The sound is that of air passing in and out of a moderate-sized cavity or chamber meeting with a certain amount of resistance. It is much the sound of air passing in and out of an elastic bottle, the size of a large pear, with an even opening of about one fourth of an inch in diameter. The blowing is generally heard during both inspiration and expiration, but in most cases it is loudest during inspiration; yet it is not uncommon to find the expiratory blowing sound louder than the inspiratory. The blowing character is found in two degrees, one gentle, and another rough and loud, or simply harsh.

The gentle blowing respiration sound I have generally found in persons having a placid circulation, and in the case of cavities free from excessive secretion and of some standing. This gentle blowing cavernous respiration sound is the condition which we usually find in those examples of the disease that promise improvement and ultimate contraction and obliteration. The extent or area of the blowing will generally serve to distinguish it from tubular respiration bruit, either of simple consolidation or of cancer of the mediastinum or the lung. It will frequently appear as if the sound proceeded from a chamber or body of air immediately under the ear. A word articulated by the patient will give, in general, cavernous pectoriloquy, the words being, as it were, "talked" immediately into the ear, if the cavity be large and superficial, or conducted with force and great vibration, when consolidated structure intervenes. When doubt still exists, a cough will produce some explosions and cavernous friction sounds which will aid in diagnosis. The true bruit de pot fêlé sound when procurable, is of value in removing all doubt. Subsequent examination is sometimes necessary, and will reveal signs perfectly decisive of the cavernous nature of the gentle blowing sound. It is to be presumed that free and open bronchial inlets, i. e. open, &c., compared with the size of the cavity and with the quantity of air drawn through them, will promote softness of the respiration blowing sounds.

Harsh blowing respiration sound is a very frequent physical sign of phthisis in its third stage. Perhaps in one third of all cavity cases this form of respiration sound is heard. The sound varies a good deal in respect of intensity in different cases. It is always what may be styled blowing. This blowing sound is loud, as of air entering into a chamber through tubes somewhat small for the quantity of air passing. It seems as if the air too were passed through the chamber and the tubes with more than the velocity that holds in cases marked with gentle blowing. The harsher blowing sound is heard for the most part both during inspiration and expiration; frequently the expiratory harsh blowing is louder during expiration than during inspiration. The loudness of this sound is much greater than that of healthy respiration. When listened to with one ear, while the other is occupied with the healthy respiration of a sound part of the lung, the latter sound is a good deal, or altogether masked by it. In some instances in which the blowing is very loud, and the healthy respiration is faint, the latter is altogether inaudible when my differential stethoscope is applied at the same moment to those parts of the chest emitting these sounds respectively.

The cases in which this harsh blowing respiration is heard, are generally far advanced, have large cavities, and are marked by dyspnœa. These examples of disease are generally pursuing a rapid and unfavourable course. The harshness depends upon coarse and rough surfaces, and upon the rapidity of the currents of air.

SAWING CAVERNOUS RESPIRATORY SOUNDS.—Sounds which answer to this title are occasionally heard in examples of phthisis in the third stage of the disease. The sound is so harsh that it resembles the noise of a saw passed with force through wood. It has been heard by me in about one cavity case in twenty. It occurs not only during inspiration, but during expiration also. The entrance into the cavity appears to be more rough and uneven than in the examples in which we observe mere harsh blowing sounds. The rapidity of the respiratory acts is also greater. The impulse is great, and the resistance is great. The resulting sound is therefore loud and harsh,—sawing as has been already said. When the differential stethoscope is employed at once over the seat of the sawing sound, and over the seat of healthy vesicular respiration, the sound of the latter is masked or eclipsed by the other; hence we have silence, so to speak, in the ear connected with the healthy lung, and loud sawing sounds in the other ear which is connected with the unhealthy lung. This sound is liable to be mistaken for very loud puerile respiration. But as it occurs only in advanced cases, it is invariably associated with dull percussion, tussive cavernous sounds or cavernous pectoriloquy, which save us from error.

CREAKING AND CRUMPLING CAVERNOUS SOUNDS.—Sounds responding to this title are frequently heard when the ear is applied either directly, or by the medium of hearing instruments, over the seat of a cavity. These sounds are such as proceed from the bending, or movement upon itself of leather or hard paper in a small chamber filled with air. They are very different from the blowing sounds. They occur in old dry cavities, and from the mechanism which they at once suggest, viz., the bending or movement of dry rather hard leather-like material. The sounds are short and coarse. Such sounds occur in cases which are in a rather favourable condition, in cavities, perhaps the seat some time before of secretion bruits, and of much activity, now in a passive condition, slowly contracting, but liable to become the source of active secretion sounds again. When the differential stethoscope is applied over a cavity the seat of such sounds, and over a healthy lung simultaneously, both ears convey impressionsto the mind. Creaking and crumpling sounds, short and coarse in their character, are heard through one ear, and full sustained vesicular respiration sounds are heard through the other. The great difference in the character of the two kinds of sounds prevents one masking the other, as happens in the case of blowing sounds and vesicular sounds, which are closely allied.

These creaking sounds are almost invariably confined to the apex of the lung. The most common seat is under the clavicle, but the sound is frequently heard above the clavicle, and above the spine of the scapula. These bruits are occasionally heard as low as the nipple. I think they are loudest when heard near the median line. I have on a few occasions heard cavernous creaking at the posterior and lower part of the thorax, but large mucous or liquid crepitation has generally obscured it. Creaking cavernous sounds are not very likely to be mistaken for other bruits, yet it is right to mention that the coarse friction sounds of roughened states of the pleura under the scapula sometimes resemble it. The cavernous character of the sound is absent in the latter conditions, if unconnected with phthisis. I have occasionally heard a sound resulting from air slowly making its way through a thick, tenacious membrane of sputum, and causing its rupture in a cavity, which has much resembled creaking, but attentive listening will succeed in the case of the former sound in recognising the bruit of a distinct rupture. The rupture sound is less diffused than the creaking. Since the above was written, I have paid some attention to this subject, and I am convinced by numerous observations that sounds closely allied to creaking proceed from film and vesicle bursting. Yesterday I heard creaking-like sounds in a girl at the hospital, having a cavity, with the wooden stethoscope. I now employed the differential instrument, with the result of making out distinct bubble rupture sounds. It would appear that the liquid of the bubbles or films, in order to imitate creaking, must be rather thick, and that the rupture must take place in small cavities, and not very superficial. It has been already stated that the audition of moist crepitation sounds, is better effected by the differential and other air instruments, than by the wooden stethoscope.

Amphoric blowing is a bruit which we occasionally hear proceeding from cavities in the lung. A similar sound has long been described in connection with perforation of the pleura covering a vomica, and is familiar to those who have had many opportunities of auscultating cases of pneumothorax. I have heard distinct amphoric respiratory sounds proceeding from cavities in some dozen cases. It is a fine gentle blowing sound, unaccompanied, indicating diffusion in a large chamber, and having a metallic or glass or porcelain tone. The sound resembles closely the noise produced by blowing lightly and rather obliquely into an empty bottle through a narrow orifice. Two conditions seem to be necessary for the production of this sound in cavities. 1. A cavity of some very considerable size, empty, or nearly empty, and possessed of comparatively smooth, thin, and vibratory walls, capable, too, of reflecting sound; 2. A narrow pervious opening.

When amphoric respiration is entirely due to the presence of a cavity, I have invariably found the case very far advanced, and in most instances, the patient has been in a rather exhausted condition. A large excavation has certainly been present in all examples, as has been revealed by the great extent of area of cavernous pectoriloquy.

The seat of amphoric cavernous respiration sounds has been under the clavicle, at the mammary and the scapular regions. I have seldom heard it below the angle of the scapula. I have never perceived it above the clavicle, the thickening and adhesions there opposing it. When it is heard in front, it is generally to be also made out posteriorly, and on the same level. Pectoriloquy of a cavernous character has always accompanied this respiration sound, in my experience, and it has had the diffused pitcher tone. The voice, with a silvery diffused quality, is wafted, as it were, by a volume of air, direct into the ear, and without sensible vibration of the solid parts of the chest. Percussion gives invariably a very dull sound. These two signs serve to prove that the amphoric respiration sound is simply cavernous, and is not due to perforation of the pleura. Under the latter accident, circumscribed pectoriloquy is not heard, and percussion is tympanitic, or empty barrel-like, over the greater part of the affected side of the thorax.

CAVERNOUS RHONCHUS.—A sound which may be thus designated, is occasionally heard to proceed from a pulmonary cavity. It is a snoring sound, as it were, passed into a small air chamber. It is the simple sonorous rhonchus, with this difference, that instead of being confined to a tube, it is passed into a cavity, and acquires a corresponding cavity character. It is most frequently heard in the case of small recent cavities conjoined with bronchitis, or with bronchitic thickening or narrowing. It is frequently of service in diagnosticating cavities of a small size, when percussion is still little abnormally affected. It is best developed by desiring the patient to make a deep inspiration. The simple sonorous rhonchus of tubes is then suddenly converted into very distinctive sonorous rhonchus of cavities. Suddenly the rhonchus bruit acquires an element of cavity character. The cavity is opened up by a strong inspiration, and the sound, hitherto confined to tubes, is carried or puffed into cavities, and to be rendered audible with cavity quality, at the exterior of the chest. I have, by means of this sound, frequently diagnosticated small cavities with more certainty than I could have done without it.

Cavernous cracking.—This is a sound which I frequently hear, and it is of some value as a diagnostic element. Frequently, when cavernous respiration blowing sounds are feeble, as is often the case when by the declension of the ribs and contraction of the cavity walls, the quantity of air introduced into the abnormal chamber, is greatly reduced, so much so as to cause little bruit, this sound will reveal the existence of the excavation. A film of thick mucus fills up the cavity opening of a bronchial tube. A little air passes through, the membrane bursts, and a crack is heard. This crack differs from mere bronchial crack in this respect, that it possesses a cavity character. Instead of a mere tubular character, which bronchitic cracking possesses, this cavernous crack has a distinct chamber quality. The cavernous character of the crack varies in respect of its extent, according to the size of the cavity. This sound is heard only when cavities are present. It is often elicted by deep inspiration, when it has been absent during placid respiration. It has been exclusively confined to inspiration, in my experience.

Metallic tinkling in cavities.—A sound nearly identical with the metallic tinkling of pneumothorax, is occasionally heard proceeding from cavities in the third stage of phthisis. I have heard it distinctly developed in some dozen cases. It resembles the sound that is produced by dropping a shot or a drop of water into a bottle having a little water at the bottom, but otherwise filled with air. It may be closely imitated by causing a bubble to rupture in an india-rubber bag filled with air. The title of amphoric tinkling would, perhaps, suffice to convey a more exact idea of its nature and character than that of metallic tinkling. The sound is clear, prolonged, gently silvery ringing, and of a metallic tone; its area is extensive. It is produced in a cavity, and it impresses this fact upon the mind; and the walls of the chamber consonate with the aeriform sound, i. e. the sound that is originated in the air of the cavity. The metallic or amphoric tinkle acquires its metallic character from the complete reflection of the sound from, and the consonance of, the walls of the cavity. The walls, when this sound is produced, are comparatively smooth, and free from that spongy, soft, porous condition which serves, as it were, to absorb sound and sensibly to muffle it. When amphoric tinkling is heard in a cavity, the patient is generally not far removed from the fatal termination of his disease. Yet I have heard it in a man (Watson) who was under my care at the Hospital for Consumption, some months ago, who presented a fair appearance, who was able to walk about, and who still entertained great hopes of his ultimate recovery.

The mechanism of amphoric tinkling is this: — At the bronchial entrances of a cavity, thin liquid in small quantity is present; when the chest expands during inspiration, a thin vesicle or film is formed; the air passing on, the vesicle or film is ruptured in a sharp manner. An explosion sound is produced: this is passed through the air in the cavity, and is very completely reflected by the somewhat hard, even walls of the morbid chamber, and by the liquid, if any, which may be present at the lower part of the cavity, the walls themselves likewise consonating. The amphoric tinkling of cavities is, for the most part, heard only only once during one inspiration. It may be repeated, but this is rarely the case. It is not unlikely that a bubble bursting *in* such a cavity may produce this sign. This sign is not continuously present in most patients who afford it. It may be present during a few inspirations only, or it may exist for half an hour or an hour, and then become inaudible for some time. However, careful examination will generally discover it some time each day. Proneness to intermit is a strong feature of this remarkable respiratory sign. The frequent dependence of this sound upon the presence of secretion at the cavity extremity of a bronchial tube will suggest an explanation of the inconstant presence of it. Secretion may be one moment arrested or coughed aside, while it may be again present within a very short period. When this sign is coincident, as it almost always is, with the inspiratory act, the mechanism is exactly as has been above explained. But metallic or amphoric tinkling occasionally occurs in cavities once now and then, perhaps once in half an hour, or it may occur in rapid succession totally irrespective of the inspiratory act. When this sign thus manifests itself, it depends upon the bursting of a bubble in a large cavity with the physical conditions I have above referred to. The vesicle is formed at the surface of the liquid which is lying at the bottom of the cavity, and it bursts at all periods of the inspiratory acts.

The seat of metallic or amphoric tinkle of cavities is almost invariably under the clavicles, towards the middle. It is rarely heard lower than the second interspace. The sound has not been heard by me, as far as I can remember, at the posterior surface of the thorax.

This bruit is incapable of being heard at a great distance from its source. It is of feeble force, and except when propagated through air and merely thin parietes, it is soon lost. This is, doubtless, the reason that the amphoric tinkling of cavities has not been heard by me through the scapula. I have observed that, in all the examples of this sign with which I have met, it has been associated with very considerable thinning of the chest-walls.

The amphoric tinkling of cavities is to be distinguished from the tinkling emanating from the pleura in pneumothorax, by the association with it of the same physical signs which accompany amphoric respiration of cavities, viz., dull percussion, cavernous respiration, and cavernous voice-signs which are very different from those which characterize perforation of the pleura in pneumothorax; these being tympanitic percussion sound, and absence of all voice and respiration sounds over the diseased side, excepting of the amphoric form. The cavernous tinkle is associated also only with the usual distress of phthisis in an advanced stage, while the other is almost invariably marked by the presence of very great and unusual suffering, which, too, has been generally of sudden or rather sudden occurrence.

Musical cavernous sounds.—Sounds corresponding to this title are occasionally heard proceeding from cavities in the lungs. They are continuous during the greater part of one or other of the respiratory acts. Their intensity is not great, but greater than that of amphoric tinkling. The sound is distinctly musical, and it may be highly agreeable to the ear in a musical sense. The musical sounds which I have heard resemble much the sounds of a musical string, or the metal plate of a Jew's harp. They are highly vibratory. They proceed from a movable solid part within the cavity, being thrown into vibrations of equal length and duration. The part thrown into vibration may be the loose edge of a bronchial tube projecting into the chamber and held in air; or it may be a loose band of fibrinous tissue stretched across the cavity; or it may be an obsolete bronchial tube or blood-vessel, loosely attached at its middle to the walls of the abnormal excavation. The force which throws these solid parts, or, as we may say, these musical chords, into vibration, is the current of air to which they are exposed during inspiration and expiration. I remember meeting with a remarkable specimen of cavernous musical sound in a female, some twelve years ago, when I was physician to the Northern Dispensary. A very large cavity, occupying the whole upper right lobe, existed in this case. After death, a band of hard tissue, one inch long, resembling a violin string, was found near the mouth of a bronchial tube. The sound, which had a metallic quality, much resembled that of a Jew's harp gently touched by the fingers. It occurred uniformly with the expiration, and lasted during the whole period of the act. This patient remained under my care for many weeks, and at the numerous examinations I made, I invariably heard the musical sound of which I have spoken. My friend, the late Dr. Manson, examined this patient. In a note which he gave he describes it as "a very decided metallic-like thrill during the whole of expiration, bringing vividly before my mind the drone of a stocking-machine, with which I was very familiar in my earlier days, in the town of Nottingham." The cavity walls were merely membranous.

The sound was that not only of a chord or metal plate, but of a chord or metal plate vibrating freely in a considerable chamber filled with air. I know of no thoracic sound that can be mistaken for the cavernous musical sound. It is true the rhonchi of bronchitis sometimes became musical, but the tone is different, and the cavity quality is always absent. The sound is always heard at the upper part of the chest. The example of the sound noticed above was heard loudest in front, but could be heard also posteriorly. As a diagnostic sign, the musical cavernous sign is of little or no value in practice, as the cavern is to be readily made out by other signs. Yet it may be useful to mention that this sign may be occasionally expected, in giving a full account of the various signs of phthisis, as I am now doing. Besides, when it does occur, the student will be able to understand it, and to associate it with its corresponding morbid anatomy.

DIVIDED DRY CAVERNOUS SOUNDS.—I have, in a few examples, heard a divided cavernous sound. The division has been marked, and has held with the expiration as well as with the inspiration. I examined a man in the hospital very lately, whose cavernous respiratory sounds consisted of three parts to the inspiration and two to the expiration. The greatest intensity was observed at the commencement of expiration. The division of the sound was so marked that it closely resembled in this respect successive systolic arterial bruits. The sounds were not arterial, neither were they cardiac, for they were not synchronous with the movements of these parts. The character of the divided sound was extremely harsh, almost grating. The cavity was situated at the left apex, and the sounds were heard along the whole under surface of the left clavicle.

LIQUID CAVERNOUS SOUNDS. — It may be affirmed that liquid cavernous sounds almost invariably signalize the first period of the cavern stage of phthisis. After continuing some time, generally weeks or months, they abate, and in numerous examples no longer exist at all. In many examples of phthisis they continue without intermission to the very end of the disease, and as they marked the development of a cavity, so they are audible at the last moments of the patient's existence. After being absent some time, it may be months, or even years, in some of the more favourable, the more chronic and enduring cases, they return and herald the fatal issue. In the acute form of phthisis, liquid sounds generally persist without intermission, or only with some degree of abatement. In chronic phthisis, on the other hand, it is common for liquid sounds to depart and remain absent for many weeks, or even years, it may be, returning for a few hours or days, at distant intervals. In young subjects liquid sounds are more developed and persist more than in older and less movable persons. In the old and phlegmatic, liquid sounds are less extensive and less durable. In females I believe liquid sounds are more habitual than in males. Some of the loudest and largest and most durable forms of liquid sounds with which I have met have appertained to young, delicate and excitable females, at the age of puberty or after an early accouchement.

Liquid sounds in the third stage of phthisis are of great value to the young auscultator; they form an easy test of the condition of the lung. Their absence frequently entails upon the older auscultator no small amount of doubt and uncertainty. Their return, speaking pathologically, is often a source of satisfaction to the oldest and most practised stethoscopist, for they place the presence of a long-suspected cavity beyond the range of doubt. With the presence of liquid sounds the existence of a cavity is frequently a matter of certainty; with their absence it is often a point of the greatest doubt, except to those intimately conversant with the different forms of deficient almost negative cavernous respiration, and with other reliable tests.

It occasionally happens to me, though daily examining many phthisical patients in the third stages of their malady, to feel that it would be a satisfaction and an additional and not superfluous confirmation of my opinion that a cavity is present, to have a cavernous secretion sound, i. e. a liquid sign. A remnant of a doubt in my mind, as to the presence of a cavity, is on an occasion dissipated by the advent of secretion, and of liquid sounds.

When liquid cavernous sounds are present, they convey at once the conviction that a cavern exists. The sounds are of the same character; they have the character of a vesicle or bubble bursting into a chamber or cavity filled, more or less, with air. The rupture sound is made out with readiness, and the air cavity or air chamber quality is distinctly appreciated. To be assured that the sound is really cavernous, the mind of the auscultator must be informed through the ear that it possesses the true cavernous character, i.e. the quality that is imparted by a bubble bursting into a chamber or cavity more or less filled with air. To know what a cavernous liquid bubble is, let the young auscultator fill an india-rubber bag, or a bladder, partly with air and partly with frothy soap and water, and let him place the bag or bladder to the ear. He will now hear the sound that I have attempted to describe.

The sound of liquid bubbling necessarily varies much with the size of the bubbles which give rise to it, and with the extent of the cavity in which the rupture takes place. If the bubbles be large—as large as peas or beans, which is frequently the case, the mind becomes conscious of the fact as to the dimensions. Such large bubbles are formed and rupture when the cavity is ample, and when the bronchial tubes which enter it are of some considerable capacity. If on the other hand the cavity is small, and the air-supplying bronchial tubes are fine, the bubbles may not reach beyond the size of hemp seeds, yet the cavernous character of this sound will be recognized by the quality it obtains by rupturing in a chamber or cavity, which is very different from the character of a sound produced by the rupture of a bubble in a bronchial tube, unless, indeed, as sometimes happens, it be greatly dilated.

The size of the cavity in which bubble-rupture sounds are produced greatly modifies the acoustic result. A small cavity gives at once the character to the rupture sound that belongs, as we know from experience, to such a physical condition. We all know from experience the sound produced by a bubble bursting into a large chamber, and when in the examination of a patient we perceive such a sound, we may be certain that a large cavity is present.

When bubbles or vesicles of large size form and rupture into a large cavity, the sound produced is much that of air rushing in great bubbles into a bottle filled with water; it is that of gurgling. When the bubbles or vesicles are small, and the cavity is small, petty gurgling is obtained; the sound of smaller bubbles bursting into a phial or small bag.

Gurgling generally takes place near the surface of the chest, and the sound conveys this idea to the mind of the auscultator. The larger the gurgling the more near it appears to be to the ear, and, no doubt, it is really nearer; for, when large gurgling takes place, it will generally be found that very much of the lung structure has been carried away, and that extensive excavation is present.

The density of the liquid through which air passes, materially affects the character of the resulting sound. The thinner the liquid the more liquid is the sound. The more thick the liquid is, the more the sound partakes of a dryish crack. When the liquid is thin, numerous bubble sounds are rapidly heard; when thick, the sound comes much more singly, so to speak.

Cavernous liquid gurgling is variable in amount. The amount depends upon the quantity of the secretion, and the amount of air supplied to the cavity and to the number of bronchial tubes conveying this air. The extent and rapidity of the movements of the parts also affect the result.

Sometimes the number of vesicles which burst, is very great; and this is observed chiefly in acute cases, and in young subjects, and more particularly in females. In old males the sound of bubble bursting, more especially, indicates few vesicles, and only moderate secretion. In children, the cavernous liquid sound indicates very frequently the rupture of very many vesicles. In many patients at this age or period of life, nothing is heard on listening to the chest, except the sound of numerous vesicles bursting into a cavity. The ear is filled with almost innumerable liquid cracks taking place obviously in a cavity.

The presence of much liquid bubbling, large or small, is indicative for the most part of active action. The disease is either at a stage of rapid excavation, or the walls of the excavation are rapidly secreting serous liquid. In some examples of phthisis, at the very latest period of life, a quasi-mechanical exudation takes place from the walls of the cavity, and from the open extremities of bronchial tubes. In such cases, liquid cavernous sounds will occur just before death, although they had not been heard perhaps for weeks or even months before.

Liquid bubbling cavernous sounds very generally abate when a cavity and its surrounding pulmonary structure are subsiding into a passive or chronic condition. An abatement, therefore, in the amount of cavernous bubbling is to be regarded as a favourable sign. However, there is an exception to this; for when the patient is thoroughly drained of blood, and suddenly becomes collapsed, and is about to die, liquid bubbling will sometimes cease. I have had numerous patients under my care, in whom liquid bubbling has ceased just before death.

The accession of liquid cavernous bubbling after an absence of some time, is generally to be regarded as an unfavourable sign, and is an indication of the return of active action, of active secretion, and often of active inflammation. This re-accession points to the adoption of those means, general and local, therapeutical and regimenal, which are calculated to abate excited vascular action.

Liquid cavernous bubbling sounds are variable in respect of duration, &c. In the first formation of a cavity and at subsequent periods, when an accession of inflammatory or excited secretive action takes place, or when in the agony of death, mechanical exudation occurs, cavernous bubbling is uniform and constant, and varies little at the different periods or stages of the respiratory movements, or with the movements of the hearts and great vessels. In many examples of phthisis in the third stage which present themselves at the Hospital for Consumption, the cavernous bubbling is uniform. It is great during inspiration, it is great during expiration, and the interval between the two acts short, extremely short, as it almost always is, brings no appreciable reduction. These cases are generally very serious ones, and they are also at the moment in a critical condition. When the cavernous bubbling is heard throughout the whole respiratory period, it often happens that this sign prevails to a greater extent during inspiration than during expiration, and more during expiration than during the brief pause that follows it. Forced and excited respiration increases liquid cavernous bubbling. A forced inspiration will occasionally develope it when placid respiration is free from it.

The act of coughing greatly increases at the moment cavernous bubbling. The sound is much intensified, and the number of explosions is increased. If we listen during the act of coughing, which is effected easily, and without discomfort to the patient, by employing my flexible stethoscope, the explosions are found to be loud and more fully driven into the ear, as it were, than during ordinary respiration. The act of coughing will frequently make manifest the presence of a cavity by developing for the moment cavernous bubbling sounds, and should therefore be brought to aid the auscultator in doubtful cases. In those cases of cavities which we may call silent, the tussive effort often awakes the gurgle as well as the cavernous resonance, and thus dissipates at once all doubt respecting the condition of the underlying lung.

Cavernous liquid bubbling sounds, besides being affected by the respiratory acts, are not unfrequently acted upon by the movements of the heart. This is more frequently the case when the cavity is seated upon the left side than upon the right. The effect is greater, as we might expect, the nearer the cavity approaches to the heart. A cavity small in dimensions at the very apex of the lung is little affected by the heart's movements in respect of bubbling sounds; but when the cavity involves the lower part of the upper left lobe, the effect is very considerable. The effect which I have observed is this: a churning sound synchronous with the contractions of the heart is heard. This is doubtless produced by the agitation and rupture of numerous bubbles in the cavity. When, as almost invariably happens in such cases, the heart's action is extremely rapid, the cavernous bubbling sound synchronous with the heart's systole is exceedingly rapid, and succeeds at equal periods of time, like the sound produced by the feet of a galloping horse. I have termed this galloping, bubbling, with perhaps questionable propriety. I have heard this form of cavernous bubbling sounds frequently: it has occurred most, so far as my experience goes, in active cases, in young females, and in persons who had only a few weeks to live. A superficial impulse of the heart, an abnormal contiguity of the heart to the thoracic surface, cavernous respiration, superficial cavernous wafting pectoriloquy, have usually been associated with this sign, and have afforded, quoad the patient, too certain evidence of the true nature of the case. The sounds which the heart's movements cause are such as are induced by the finger very rapidly, say 150 times in the minute, impinging upon a bag containing frothy liquid. The sounds have also the character understood by the term squashy, already made use of.

Squashy bubbling in a cavity is occasionally heard, and is influenced by the respiratory movements. This kind of sound is induced by rapid motion, the formation, and the bursting of very many rather small vesicles, and when the solid and liquid parts are all being mixed up together. It is much the sound which is produced by driving the finger through a soft, hollowed, putrid apple, discharging air as it passes.

Liquid cavernous sounds are well heard with the aid of solid and air stethoscopes. No sounds are better conveyed to the ear of the auscultator by means of air instruments, such as all flexible stethoscopes, than the sounds under consideration. I think I have heard them better when listened to with the aid of air instruments than of solid ones. At all events, if cavernous liquid sounds are present, they will be well explored by means of air instruments. The reason, doubtless, is this: the sounds themselves are really much of the nature of air sounds, and air sounds are more readily propagated through air than through solid media.

Liquid cavernous sounds vary extremely in their precise characters. While the sounds are all distinctly bubble and cavern sounds, and have certain features in common, it is observed that the exact character of one case differs much from that of another. Some sounds resemble the noise of gurgling, some of bubbling, some of effervescence, and some of sea foam. I lately listened to the sounds of a cavity, during ordinary respiration, in a young woman, in an active state of disease. They very much resembled the explosion of bubbles of sea water rolling amongst rocks.

SEATS OF CAVERNOUS LIQUID SOUNDS.—Cavernous liquid sounds are heard in all parts of the thorax. But it is in the upper and middle portions that they are more frequently discovered. To describe the locale of these sounds is to describe the locale of caverns, for wherever caverns exist, these sounds are made out at one time or another, and they are never heard except when a cavity is present. It might therefore be concluded that the consideration of the seat of these sounds might be postponed till I treat, as I hope to do, of the morbid anatomy of the disease. To do this, however, would be inconvenient, for the morbid anatomy cannot be treated of for some time; and it will be found useful at the present moment, to point out the localities where the sounds we are describing are most frequently met with. The seats of these sounds, too, are those of cavernous voice and respiration.

According as we examine patients, in the early, the middle, or the very latter period of the third stage of the disease, we shall find that, in respect of frequency, the localities of cavernous liquid sounds greatly vary. At the period of the first manifestation of liquid cavernous sounds, they are almost invariably met with above, and immediately below, the clavicle on one side of the chest. When loud, they are also heard above the scapula and over it. In very few examples of phthisis do we perceive these sounds, at an early period of the third stage, below the border of the third rib. At the base of the lung, such sounds are scarcely ever heard at this period. I have discovered them in only a very few examples, bearing an extremely small proportion to the cases of phthisis which I have examined, perhaps not more than once in 500 cases.

When cavities have arrived at the middle period of their course, liquid cavernous sounds are heard much more frequently below the third rib, and on a level with the nipple. Still the frequency is much short of that observed above that point. When cavities are old, and the patient is in a dying state, or one approaching it, it is extremely common to hear the sounds of cavernous bubbling as low as the lowest border of the mammary region in front, and near the angle of the scapula behind. At the infra-mammary region, and in the inferior lateral and inferior dorsal regions, cavernous bubbling sounds are not unfrequently heard at the same period of the third stage of phthisis, i.e. of the cavity stage.

At the first period of the cavity stage, liquid cavernous sounds are almost always confined to one side of the chest; they are occasionally discovered upon both, but rarely. At the second period of the third stage, it is not uncommon to find these sounds on both sides of the chest at the upper part, generally lower on one side than on the other, the side on which the sign is lowest being in general that first affected. When the patient is dying, after a long period of exhausting disease, cavernous liquid sounds are very frequently found upon both sides of the chest, it is true generally to a greater extent, and extending lower down on the first affected side than upon the other. I have found these sounds on both sides, more commonly in women than in men. Of the two sides of the chest, the left appears to be a little more frequently the seat of these cavernous signs than the right.

Of fifty-two of the out-patients I examined in 1859, and taken consecutively, suffering from phthisical cavities, twenty-six afforded the signs exclusively on the left, twenty exclusively on the right, and the remaining six presented them on both sides. Of the six with the signs on both sides, five were females, and only one was of the opposite sex. It may interest the reader to know the ages of these six patients. The male was 22, and the five females were respectively, 16, 39, 28, 35, and 21.

The course of cavernous liquid sounds is this; they generally begin above, occasionally they commence at the middle or at the apex and middle together, and very rarely at the base.

It is even very rare for the apex and the base to give out these sounds together when they are first developed. The almost uniform tendency of liquid cavernous bubbling sounds is to travel downwards, and to invade the side opposite to that on which they commenced.

These sounds are usually heard at the back, at a level corresponding with their seat in front, but they are generally more faint behind than in front. Occasionally they are more loud at the scapular region than under the clavicle.

If we judge of the localities of bubbling cavernous sounds by the observation of patients only who come into the Hospital for Consumption, we arrive at somewhat different conclusions from those above described. The actual condition of patients admitted into the hospital does not exactly represent the comparative frequency of the first or even the early development of these sounds. It tells only of the present presence, and says little of the order in which the different parts have become the seat of them. In a large proportion of the cases which come into our hospital, the cavity stage has arrived at its third period, and in these cases we very frequently find cavernous sounds simultaneously in the upper and in the middle of both lungs. The locale of these sounds becomes gradually extended with the progress of the disease. In almost every example of the malady in which we find cavernous liquid bubbling sounds in the mammary region, there can be little or no doubt that in respect of this locality it is a recent sign compared with the same sign in the upper part of the thorax. In other words, these sounds had most probably manifested themselves above and below the clavicle first, and only secondarily in the mammary region. It is to be borne in mind that, where liquid cavernous sounds are actually heard, they may not have been present at the very first development of them. Of the primary seat and the local progression of cavernous bubbling sound, we judge from the continued examination of the same cases from the beginning, and not from the observation of examples of the sounds as discovered in advanced cases only, which are the cases of the malady most frequently brought under the notice of the physician in hospital, and in consulting practice.

The mechanism of cavernous liquid sounds is so obvious that it seems almost supererogatory to explain it. The very hearing of the sounds suffices to explain their production. Liquid exists at the cavity entrances of the bronchial tubes, through which air is passed by the expansion of the cavity and of the chest. The agitation of liquid in a cavity with the air which is being constantly drawn into it, gives rise to the formation of vesicles or bubbles, and the rupture of these bubbles and the motion of air through the liquid are attended with sounds now under consideration.

Gurgling sounds are produced by the sudden contact of air with liquid and the motion of the air in its ascent to the surface, and the rupture of the water membrane.

Tussive or cough efforts will cause numerous bubbles or vesicles floating upon a liquid surface to explode at once, which would probably have remained intact for some time, or have exploded only singly and without violence.

When the cavity is small, the resonance will indicate a small area resonance. When large, a large area resonance. When the cavity is filled or nearly filled with mucus, pus, or other liquid materials, the sound of explosion will not be great. If on the other hand the cavity be empty, or more properly speaking filled with air, the sound of bubble explosions will be louder. When the cavity is irregular, spongy, and soft, the reflection of sound will be slight, and the character of the sound will be soft, with comparatively little reverberation. When on the other hand the cavity has walls which are thin, smooth and hard, the reflection will be ample, the resonance will be great, and the tone will acquire a metallic character; i. e. the sound of a hard vibrating body, such as glass, plates of metal, and membranes that are tense.

Tussive or cough cavernous sounds are of value in the discovery of phthisis. When respiration through a cavity is silent, so to speak, and when bubbling cavernous sounds are not heard during ordinary respiration, the sounds under consideration prove of great use in diagnosis. They are often of the greatest use when percussion is not materially dulled, and when pectoriloquy, either from the obliteration of bronchial communication or from the cavity being nearly filled with liquid, is not established.

The sounds produced by cough in the area of a cavity, and which communicated to the thoracic walls are heard by the auscultator, and that aid him in his diagnosis, are of two kinds; 1, dry blast sounds, and 2, liquid bubble sounds.

Blast sounds are almost always heard over the seat of cavities during the act of coughing. The sound is that of air driven in some volume against the walls of a cavity or hollow chamber and against the openings into it, and of air rushing from the excavation. The expulsion is caused by the sudden descent of the ribs under the convulsive action of the expiratory muscles. The air in the chamber is suddenly and violently compressed by the walls of the cavity, and so far as is possible, escapes, attended with a rushing noise, such as I have designated a blast. When the air stethoscope is employed, a sudden blast or rush of air takes place as it were into the instrument and into the auscultator's ear. The character of the blast sound varies with the size of the cavity. When the excavation is large, the blast sound appears to proceed from such a chamber, and when small, this is equally indicated by the area, so to speak, of the sound. Sometimes the blast sound is mingled with a little crepitation or gurgling. It is in old cavities that the blast dry sound is chiefly obtained. When a cavity is small and rather deeply placed in the pulmonary structure, the blast sound is only imperfectly cavernous, and resembles the sound of tubular rushing sound of large bronchial tubes in bronchitis and in nervous cough common in females, particularly the young and hysterical. But the absence of pectoriloquy, and the presence of clear percussion sounds in the latter case, serve in the diagnosis very effectually.

When the cavity is large and superficial, the tussive effort produces such a dry blast sound as is at once conclusive of the condition of the lung, and such as is never heard under other circumstances. The blast is close under the integuments, and is communicated with force, and as with a volume of air, into the ear of the auscultator.

The moist sounds produced by coughing, when a cavity is present in the lung, are cracking and bubble noises. Numerous loud explosion sounds are heard in almost all cases in which liquid cavernous sounds, even to a moderate extent, have been audible during ordinary respiration. Sharp gurgling sounds are common, even when no such signs are ordinarily heard, and they serve materially in the determination of the question of the presence of vomica. These gurgling sounds are driven, as it were, through the stethoscope, particularly air-ones, into the auscultator's ear.

When the cavity contains a good deal of air and liquid, and there has been much violent cough, calculated to mix these bodies together, a violent cough will occasionally produce a sound like that which attends the sudden discharge of the froth and bubbles of a suddenly uncorked bottle of effervescing liquor. This is a sound of rushing froth, partaking of a cavity character. I have, in several cases, heard this sound. It is conclusive of the presence of a cavity; and when I have detected it, there has always been present evidence of very active disease, and of great bodily suffering. I have found it only in young persons, and almost exclusively in females of an excitable as well as excited system. Hectic fever has always attended it, and to a very considerable extent. It is not to be confounded with the rushing froth sound of severe capillary bronchitis, which has no cavernous character, and which is chiefly heard at the base of the chest in young children and in a few very old subjects.

The following table exhibits the various kinds of the chief respiratory cavity sounds appertaining to twelve of my hospital patients examined the same day:—

Gentle Dry Blowing.	Chamber Sounds little audible.	Harsh Blowing.	Gurgling.	Gurgling and Blowing.
5	4	1	1	1

CHAP. XXVII.

THIRD STAGE — *continued.*

Thoracic Voice. — Strong vibrating Voice. — Direct air medium Voice, or true Pectoriloquy. — Impaired Voice. — Use of Whispering. — Amphoric Voice. — Quasi Ægophony. — Ægophony: its Mechanism. — Reduced basic Voice.

THORACIC VOICE. — The voice, in a large proportion of cases of phthisis arrived at the third stage, is very sensibly modified. The abnormal alteration holds in a larger proportion of cases of phthisis in this stage than in either of the two preceding. There are three chief forms of alteration directly appertaining to cavities which I have observed: 1, increased loudness; 2, increased distinctness and proximity to the ear; and 3, partial suppression. The amphoric and the ægophonic voices of cavities, and the ægophony of empyema occurring in phthisis, will be separately considered. The amphoric voice of pneumothorax, always treated of under the third stage, I shall describe under the fourth or perforation stage.

The first alteration is very common; and is more especially the voice of small early cavities in the midst of dense pulmonary structure; the second is the voice of large superficial cavities; and the third appertains to old contracting or contracted cavities, whose walls are brought comparatively together by the contraction of fibrous exudations, and by the pressure of the depressed and comparatively immovable ribs, and by the partial obliteration of the bronchial entrances, and the consequent diminution of air communication and of air supply.

The first form of voice is very commonly observed: few examples of small cavities present themselves without its being more or less clearly manifested. The presence of a cavity small in size permits of the entrance into the lung, in an abnormal manner, of a large body of air vibrating in consonance with the air in the larynx and trachea. This amount of sounding air is more able to affect the surrounding condensed tissue than the air normally contained in bronchial tubes. These solid parts now participate in the vocal vibrations, and communicate them again to the thoracic walls. This form of voice is not always very distinct, but it is remarkable for loudness and strength of vibration. By distinct, I mean the clear and sharp character of sound, free from sustained resonance, or undue mingling of sounds, heard distinctly either as they proceed from the mouth, or from a large superficial cavity, in which cases words are well articulated. A humming quality is usually associated with this form of voice. Cavities the size of walnuts are usually attended with this quality of thoracic voice, if, as is usually the case, they are covered by dense or consolidated or even moderately congested lung. When these small cavities are developed near the surface of the lung, and come close to the thoracic walls with little interposed pulmonary structure, they do not communicate this form of voice; but, on the contrary, the second named form (or an approach to it), viz. that of great distinctness, and of distinct articulation, but only over a small area, not larger than the object extremity of the ordinary stethoscope.

The loud and vibrating voice of small and early cavities is extremely like the augmented voice of the well developed first and second stages of phthisis. In the voice of all these conditions, we observe loudness, force, and undue vibration. The voice therefore of the third stage, with small cavities, is *per se* not easily distinguished from the voice of consolidated or softening lung. To our aid come, however, liquid bubble sounds, and when cavities are present, the cavity quality being imparted, the diagnosis is rendered easy and obvious. A cough in the case of the loud vibrating voice of small cavities, will often at once reveal the presence of tubercular excavation. The seat of this strong loud voice, or of the voice of small circumscribed cavities, is more varied than that of the other forms of abnormal phthisical voice. It is more partial, less extended, and more confined to a part, than either of the other modifications of the thoracic voice in phthisis. The most common seat is under the clavicle; very frequently it is heard above that bone. It is by no means uncommon at the various parts of the scapular region. It may be observed above the clavicle while it is absent below it, and it may be heard at the scapula when it is absent or inaudible at the infra-clavicular and mammary regions. It is rarely heard in the axillæ, and more rarely there only. In a word, it may be said that this form of voice is heard exactly where cavities are wont to begin, and I shall, I hope, in a subsequent work, indicate the points thus selected for commencing excavation. This phthisical voice resembles bronchophony, and it is to be remarked, that it will not be developed if the voice be naturally very weak, or if laryngeal disease cause it to be very hoarse or whispering.

The second form of abnormal thoracic voice in the cavity stage is a very remarkable one. Heard with the unaided ear, or with the assistance of any form of stethoscope, it has properties which, in the case of a mind acquainted with the natural thoracic voice, make a great impression upon it, and lead to the conviction that the soft spongy structure of the lung is destroyed, that there exists under the ear an abnormal cavity filled more or less with air. The acoustic and therefore the physical conditions of the contents of the thorax, the auscultator becomes convinced, are greatly altered from their normal state. The sound of the laryngeal voice — the sound of words — reaches the ear as if the medium, the ordinary solid medium, viz. the lung structure in its normal state of partial inflation through which it passes, were removed, and it arrived without the usual arrest and decay incident to its passage. This difference may be satisfactorily imitated by placing a self-adjusting flexible stethoscope in the ear, such an instrument, as Camman's or my own, lightly holding a small cushion loosely stuffed with feathers or wool before the object extremity of the instrument, and then speaking through the cushion. The voice will reach the ear distinctly; but it comes muffled and decayed, and partially arrested. Remove the cushion, apply the mouth to the stethoscope, articulate a few words; these words are wafted or spoken into the ear with characters which indicate the removal of all solid impediments, and that argue an uninterrupted medium of air only. The characters which attach to the voice heard during the latter experiment, are precisely those that hold in the case of the thoracic voice, of which we are speaking, i. e. the voice of the second form. It is true that it is only in the case of the larger cavities, and of those having free air communication with the larynx and trachea, that these characters are fully and perfectly developed. But in this form of thoracic voice, if the characters described are not so completely developed as in the experiment, they are at least easily to be discovered, holding to a very considerable extent, but varying in degree in different cases.

The extent to which the completeness of the air medium character holds, varies much in different examples of phthisis in the cavity stage. In some cases, the voice reaches the ear with all the direct and unimpeded air medium character which we find in the experiment of speaking direct into the stethoscope; thus the interposed intercostal soft parts, the pleura, the walls of the cavity, and the rib under the stethoscope going for almost nothing as sensible mufflers of sound. In other cases, the direct air medium character of the voice, so to speak, is somewhat less, and the parts just enumerated do succeed after the manner of health, in muffling to a sensible degree, and in otherwise affecting, the voice as it is passed through the chest. In another class of cases, small certainly, the direct air medium character of the voice is so much impaired, or rather has been established so incompletely, and so much of the natural muffled character of the voice is retained, that it is rather difficult to say whether the voice really be cavernous, and belong to the form of voice of which I am now treating. When the voice is thus doubtful, a short period frequently suffices to bestow upon it sufficient of the character of direct air communication to remove all doubt. The excavation goes on, the supply of sound-conveying air is increased, and the walls of the cavity are becoming thinner, and less able to arrest or modify vocal sound, or to impart to it the characters of transmission through a solid body. Hence it is that a voice heard at one time simply increased in loudness and force, and destitute of the direct wafting character, &c., becomes after a time endued with this characteristic in a perfect degree, so much so that the voice, however weak, or if it be even whispering, is plainly and clearly and articulately conveyed into the ear of the auscultator.

The perfection of this direct air-communication character, or the perfect cavernous character of the voice, if for the sake of convenience in writing we may so style it, is due to various conditions. The elements for perfect cavernous voice are these: — A. A large cavity; B. Even thin smooth walls of cavity; C. Air to a large extent in cavity; D. Free bronchial communication; E. Thin thoracic walls.

When all these conditions are present and in force, the cavernous character, or direct air communication feature, is most perfectly developed. When there is a large cavity, but the walls are thick and spongy, this character is less developed. Thick thoracic walls moderately impair the characteristic sign, but this seldom or ever succeeds in destroying it. Impaired communication between the cavity and the trachea and larynx is very operative in preventing the development of this sign. Laryngeal disease and obstructive tracheal disease, and the partial or complete obliteration of bronchial tubes at the cavity, will interfere with the development of this cavernous voice, while a simply weak voice, without obstructive changes, or a voluntarily whispering voice, will permit of the perfect development of this remarkable sign. The communicated voice is weak or whispering, it is true, but it is distinctly cavernous, most distinctly articulated, and is otherwise possessed of the direct air communication character.

It is this form of cavernous voice that specially admits of being heard when the patient whispers. The feeble voice of the whisperer meets with so little obstruction calculated to impair its little force, that it succeeds in reaching the exterior of the thorax with a strength that still renders it audible, with all its characteristics, to the careful auscultator. That so weak a sound as the whispered voice should be heard on the exterior of the chest, is not really extraordinary. The cavity, the bronchial tubes, the trachea, and the larynx form really only one pipe or tube. The thoracic walls now impede the transmission of sound no more than a thickish membrane would impede the transmission of sound through the further extremity of a speaking trumpet. In fact, the larynx, the trachea, the bronchial tubes, and the cavern, under the circumstances described, may be truly said to form a speaking trumpet. A whispered word passed into a speaking trumpet, is heard distinctly at the free extremity.

This form of thoracic voice is occasionally characterised by a metallic or amphoric tone. The voice comes to the ear as if reflected sharply from hard and smooth surfaces of a chamber larger than ordinary. The solid walls seem to consonate. I perceive this character in one case of cavity out of about every twenty. The examples in which it is discovered are generally chronic, and are those of adults or old subjects, occurring more in males than females. I have heard this metallic amphoric tone twice in one day in my wards at the Hospital for Consumption.

The seats of this articulated direct voice are generally the upper parts of the chest, occasionally the base. It is extremely common to find it above the clavicle, below it down to the nipple in front, and posteriorly reaches as low as the angle of the scapula. It is more distinct in front than behind. It is sometimes audible in front when it is not audible posteriorly, but if well marked, this is seldom the case. I have occasionally heard the thoracic direct voice behind, when it has been inaudible in front. This suggests the great importance of posterior examination, in addition to that made in front. But I must confess that, in cases of cavities, I have not heard this form of voice developed behind and non-developed in front in more than about one in fifty cases of cavity. I have seldom met with direct air medium cavernous voice in front lower down than the nipple, but I have heard it not unfrequently a little below the angle of the scapula posteriorly. Perhaps in one out of one hundred examples of cavity, I have heard this form of voice below the level of the scapula and posteriorly.

I remember hearing the voice at this seat in the case of a young lady (K.), in good general health, who was supposed to suffer from "hysterical cough" and "disorder of the liver." This was the only physical sign which was well marked. It revealed, I need scarcely say, the fortunes, or it may be more truly said, the misfortunes of the patient. She died of hæmorrhage almost immediately after its discovery.

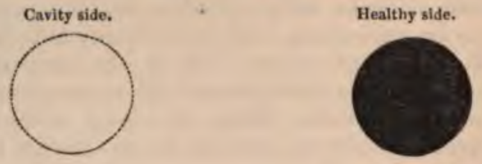
This sign is the true pectoriloquy, as this was originally understood by auscultators. As a sign of phthisis in its third or cavity stage, it is pathognomonic or significant of cavity, and without exception. No sign in medical physics is more sure and infallible than this. Had the term pectoriloquy, as signifying a cavity, been restricted to this sign, and had not been extended to the form of voice accompanied with strong vibration, and simply remarkable for loudness, none of those mortifying and injurious mistakes would have happened, when physicians, regarding simply intensification of voice as proof of cavity, pronounced consolidation to be excavation. If pectoriloquy is to be held as certainly indicative of cavern, this is the only commonly observed form of voice which should be so designated. The amphoric and ægophonic forms of cavity voice and the amphoric pleural voice of phthisis in its fourth stage are also conclusive, but they are comparatively of very rare occurrence. But as every form of voice heard through the thoracic walls is strictly entitled to be designated pectoriloquy, the word signifying voice heard through the chest, it is better to designate it as cavernous direct air voice, and so call it after its real and cavernous nature.

It seems needless to say that this form of voice is pathognomonic only in a positive sense. When present it infallibly indicates a cavity. But when absent this fact is far from proving the absence of a cavity.

The third form of thoracic cavernous voice is the impaired voice. In this form of physical sign the chief characters are feebleness and indistinctness. The frequency of this form of cavity voice is not very great. It occurs amongst my hospital patients with cavities in about one in twenty cases. I have at present under my care two examples of old cavities, revealed by the presence of cavernous, comparatively silent respiration, so to speak, great depression of the chest and tussive explosive bruits, in which this impaired voice is present.

The voice is never so impaired as to be altogether inaudible with the single stethoscope, but the impairment is decided, in some cases very decided. The deficiency of voice is best made out by the employment of my differential stethoscope in auscultation. If we listen successively by means of this instrument, employing one limb on the diseased side and then the other limb upon the healthy side, the difference is well ascertained and appreciated. Further, if we listen to the thoracic voice at corresponding parts of the two sides, one being healthy and the other being the seat of a cavity, and there be present at the latter part a deficiency, such as we are treating of, no voice will be heard with the ear connected with it, but much voice will be heard with or through the ear connected with the sound side. The absence of voice on the diseased side is sometimes extended to the base of the lung where no cavity exists.

The acoustic circles represent the acoustic results. The black circle represents sound or heard voice, and the dotted circle represents silence.



The absence of auditory sensation of cavernous voice, when the differential stethoscope is thus employed, is by no means so frequent as the absence of sensation of cavernous respiration. While absence of sensation of cavernous respiration is exceedingly common, the absence of voice sensation is comparatively infrequent, occurring, as has just been stated, in about one in twenty examples of cavity among my hospital patients.

This form of impairment of the voice, where a cavity is present, appears to be due to the absence of free air-communication between the trachea and the cavity. Little air may be admitted into the cavity from the compressed state in which it may be held by the depressed ribs, and by adventitious adhesions preventing the possibility of inflation. Again, the bronchial apertures may have become so occluded by inflammatory action and casts as to supply air in too insufficient a quantity to impart sufficient vibration to the solid parts to produce the usual audible sound.

The impairment of voice here referred to is not to be confounded with the weak voice of disease of the larynx or of debility. The weak thoracic voice, dependent upon these latter states, is known by the weakness of the oral voice heard through the air, and by the thoracic voice being impaired over every part of the chest.

The absence of cavernous pectoriloquy in suspected cases of cavity, when hoarseness and whispering voice have been present, has repeatedly led to error by causing the auscultator to conclude that no cavity was present. These conditions of voice seldom admit of the development of very unequivocal cavernous thoracic voice. The question as to the presence of excavation must therefore be solved when this form of voice is absent by other tests. If these be inconclusive to-day we must wait before giving a decided opinion. I have known many cases in which physicians have brought discredit upon themselves and upon physical exploration by attaching a weight to this negative evidence that does not properly appertain to it. I have had many patients under my care at the hospital who, being in good general health and in good general condition as to flesh, suffered from laryngeal disease, causing weak, hoarse, or whispering voice; and who, having no marked cavernous pectoriloquy, would have led me to pronounce the absence of excavation. I had a year ago an out-patient under my care who looked well, but whose voice persistently remained hoarse, weak, and dissonant. I could make out no excavation voice. I suspected, though I could not discover, a cavity. Going round Dr. Quain's wards one day lately, at his request, I saw this patient, and on examination the presence of cavity was fully shown, not by cavernous voice, but by cavernous gurgling, &c. At this moment there is under my care in the Paget ward, a fine looking young man, fleshy, and of florid complexion, of jaunty air, and lively manners. He came into the hospital with whispering and hoarse voice; examination of the chest was inconclusive as to excavation. The voice remaining unimpaired, suspicion of pulmonary excavation increased; repeated examinations were made, and it was only lately that the existence of softening of the lung and of excavation was conclusively discovered. If anything can bring discredit upon a young physician, it would be overlooking the possibility and even the likelihood of excavation under such circumstances. He cannot be too much upon his guard in respect of this, or trust too little to the absence of cavernous voice, particularly at his first exploration, as evidence of the healthy state of the lung.

When the voice is marked by very much vibration and, as it were, with solid elements of sound, which is not unfrequently the case, the patient should be directed to speak in a whisper. The strong vibration is now avoided, and the distinct and clearly articulated superficial voice below the integuments, so to speak, will be wafted direct into the ear of the auscultator. I have, in numerous examples of cavities, in which the voice pronounced at its ordinary pitch caused a thoracic voice so strong and vibratory, that I have been in doubt as to whether the morbid condition was one of solidification or of cavity, and in which a whispered voice has completely solved the difficulty, giving the distinct cavernous superficial voice without the vibration and the sounds of adjoining solid parts. The strong voice as heard through a cavity, through its walls and the walls of the chest in strong vibration, may mask feebler cavernous air sounds, which would readily indicate the true anatomical condition. By whispering this is avoided, and the decisive, though feeble cavernous sounds, are allowed a hearing. The feeble whispering voice agitates the cavity air only, the strong voice throws the solid parts also into strong vibration, and suggests merely solid conduction.

AMPHORIC VOICE, OR AMPHORILOQUY OF CAVITIES.—The cavernous direct pectoriloquy, or thoracic voice of the third stage of phthisis, occasionally is found to partake of a hollow vessel, pitcher, or amphoric tone. I have heard this kind of cavernous voice more than a dozen times. It is usually associated with amphoric respiration, or respiration sounds having the same resounding or thin metal sheet ringing tone. The voice is not strong; it is a diffused chamber-like sound. The diffusion, however, is much less considerable than the diffusion of the amphoric voice of perforation. The tone of the amphorism of cavities is much the same as that of the pleural cavity, although less marked in general. The amphoric tone, I must however say, has been as highly, as strongly, and completely marked in mere cavity cases as in examples of pneumothorax depending upon perforation. This cavity amphoric voice, like the amphoric respiration sounds of cavities, has been heard by me at the upper part of the chest. It has a large range from the clavicle down to the third rib, and is heard usually behind as well as in front. The cavity which emits this kind of voice is always large. I believe it to have thin, hard, and smooth walls, to contain little if any liquid. Finger dulness, or something near it, is always present, and the true cracked-pot sound is to be elicited in about fifty per cent. of cases of this sign.

QUASI ÆGOPHONY OF CAVITIES. — I have, in some few examples of phthisis, heard a quasi ægophony, altogether independent of effusion into the cavity of the pleura. It has only a moderate amount of tube squeaking character, but there is much vibration or trembling with it, and it is loud and like true ægophony near the ear of the auscultator. It has occurred in the case of very large cavities only in my experience. The usual seat has been the upper part, mammary region, and towards the axillæ. I have been assured of the existence of cavities by the presence of whispering pectoriloquy of the usual character, prior to the advent of this quasi ægophony, and of hollow cavernous respiration sounds. I met with an example of this quasi ægophony in a gentleman who died of phthisis in the third stage a year ago. The voice trembled exceedingly. When this form of cavernous voice occurs, it is obvious that the mechanism of the bronchial openings and of the thin walls of the cavity are promotive of more than usual vibration.

ÆGOPHONY. — This is one of the most remarkable of the remarkable physical signs observed in the third stage of phthisis. It is heard very rarely, and only when effusion has taken place into the pleura. Some physicians, it is true, believe it to be occasionally produced when consolidation only is present. This necessary effusion is in a very large majority of examples of this sign, sero-purulent, and is the result of pleurisy. In some few examples I have known the liquid to be only serous, but in these examples the sign has never arrived at its most complete state of development. The character of the effusion has been ascertained after death. The sound of the ægophonic voice resembles the bleating of a sheep, or of a goat, and it is from this latter resemblance that it is indeed designated Αἶξ, *αἰγὸς*, capra. It possesses the trembling character of the bleating animal. A squeaking character enters into its composition, and the voice certainly resembles in some measure the squeaking of Punchinello. It is as if the voice, after being formed, were transmitted through a narrow tube and through a solid body in a state of tremor or trembling.

This form of voice is difficult of description, but when once heard it is not likely to be mistaken for another sound. The chief seat of this voice is the middle of the chest, and a little below it; far most frequently at the posterior aspect. Its most frequent point of development is the angle of the scapula, over the scapular region, and extending to the spinal column. It is very seldom heard above the spine of the scapula, and is developed more externally than the outer edge of the scapula. In few instances has it been heard in front in phthisis, but in one or two cases I have heard it at the mammary region. The adhesions of phthisis are likely to prevent the frequent discovery of this sign high up in the thorax. The voice is loud, and it seems superficial.

The anatomical and pathological conditions when this sign is present are these: effusion, mostly sero-purulent, occasionally serous only; a collapsed and somewhat solidified and compressed condition of the lung; immersion of part of the lung in the liquid, pressure of the bronchial tubes by the liquid sufficient to narrow them, but not totally to occlude them; laryngeal voice of some force.

The ægophonic voice is essentially a temporary one. In the case of some patients, it may have one period only, or it may have two. That is to say, it may appear, and after some days disappear, never to return; or it may appear, last a few days, disappear, and then, after a week or two, it may return, but to disappear finally after some days. Ægophony of phthisis in the third stage not uncommonly remains till the time of death. When it has only one period, the duration is generally greater than when it is to return. When of a single period only, it is heard as soon as the effusion has reached as high as the level of the angle of the scapula. As long as the liquid reaches no higher, and is not materially reduced, the characteristic voice remains. When the effusion notably reduces, the voice with its singular characteristics disappears. When the voice has a second period, the effusion proceeds to a great extent, its level rising as high in some cases as the third or even the second rib. As soon as the liquid level has attained the level of the fifth rib in front, the characteristic voice is lost, but as the liquid abates by absorption, and the upper part of the lung and the bronchial passages are liberated from compression, the voice again returns, but generally only for a few days, for the process of absorption proceeding, liberates the lung and bronchial tubes altogether from compression, and puts a stop to that immersion of the lung which is essential to the development of the true and perfect ægophonic sign.

The ægophony of phthisis in the third stage is generally associated with cavernous respiration, feeble and more obscure, it is true, than before the effusion, or after its total absorption. There is usually some cavernous voice at the apex. The percussion sound is absolutely dull from the base upward to the seat of the ægophony; respiratory sounds are absent or faint, or as if distant. There is a total absence of any kind of voice for the most part at the very base of the lung. The semi-diameter of the chest is increased; the ribs move little, and the aspect of the side is more rounded than usual, and the interspaces are fuller. When ægophony disappears, this may be due to increase as well as decrease of the effusion; the travelling of dulness and of silence, so to speak, upwards marks increase; the travelling down of these signs, and their mitigation or reduction, indicates the decrease or absorption of the liquid.

Ægophony almost invariably takes place upon the side of the chest which is the seat of cavities; but though I have not seen an instance of it, there appears no reason why it should not be heard on the opposite side, where no cavity exists, and yet owe its presence to pulmonary tubercle disease. The ægophony of phthisis is more frequently found in the third stage of the disease than in any other, but it is occasionally heard in the first and in the second. In the fourth stage, though effusion is present in a very large proportion of cases, I have not heard ægophony in any one instance, the presence of air in the pleura counteracting the influence of liquid, quoad ægophony. I have, partly on these grounds, preferred describing this sign in connection with the third stage of the disease.

The mechanism of ægophony has excited much attention, and little approach to unanimity is to be found in respect of it amongst physicians. It appears to me to be unnecessary to detail the various views of auscultators on this sign. The explanation which I have to offer is this, and I believe it to be at once consistent with the laws of sound, and with the pathological conditions under which it is found.

In the first place, the force of the voice when it has reached the bronchial tubes at the mid-chest, is unduly augmented. The diffusion of the sonorous undulations through the lung is partially prevented by the solidification always present; the bronchial tubes are more freely brought into vibration, and this adds to the sound. The constricted punchinello squeaking character is imparted by the compression, partial it is true, of the bronchial tubes, particularly at their posterior and membranous part. The liquid compresses the tube, narrows its calibre, and so imparts the characteristic squeaking sound. The compression is, however, of so feeble a character that the unduly strong voice is sufficient to throw the parts into undue vibrations, and the articulated sounds are propagated in a trembling manner.

The trembling begun in the bronchial tubes is communicated to the solidified lung lying loosely immersed, in part at least, in the liquid. The trembling is continued, favoured by the little resistance of the liquid, throughout the middle of the lung and thence to the liquid itself, and lastly to the thoracic walls. There is just that amount of resistance from the liquid to recoil the lung after its excursion, so to speak, under the force of the voice. The voice force and the liquid compression force are so nearly equal, that a system of vibrations is established. Less compression upon the air tubes and less voice would not suffice to freely vibrate the tubes or the lungs, and more compression would be fatal to vibration of these parts. This may be imitated; a flexible tube of indiarubber compressed at a part very feebly and a feeble voice will give no squeaking sound; a little more pressure and a little more force of voice will impart the squeaking character. Press more firmly, so as nearly to obliterate the tube, and the squeaking character will be lost. So we find in respect of ægophony, a little liquid developes the sign, and a great deal removes it.

REDUCED VOICE AT THE BASE.—In a very large proportion of examples of phthisis with cavities at the apex, the thoracic voice at the base, as has been already incidentally stated, is much impaired. This holds when the base of the lung is condensed and the bronchial communication is reduced. The comparative weakness of the voice of the diseased base is well made out by using the differential stethoscope bilaterally and at the same moment. In many examples, no voice whatever is then heard on the diseased side. There is no doubt that the reduction of the voice is due to the reduction of air-communication. I have listened for the sounds of a watch and a tuning fork proceeding through consolidated lung out of the body, and have found that their intensity was increased when a hole, the calibre of a large bronchus, was made through it, and the stethoscope placed over the aperture. The difference was very great when the flexible or differential instrument was employed; less so when the wooden stethoscope was in use.

The total abolition of the voice at the base in the third stage of phthisis is uncommon. It is found in those rare examples only in which effusion to a large amount has taken place in the pleura. Ægophony at the angle of the scapula and finger dulness on percussion mark these cases.

CHAP. XXVIII.

THIRD STAGE — *continued.*

Bronchial Sounds. — Constrictive Sounds. — Moist and liquid Bronchial Sounds. — Laryngeal and tracheal Sounds: Tracheal Ticking and laryngeal Constriction Sounds. — Pneumonic Crepitation.

BRONCHIAL sounds, in the third or cavity stage of phthsis, are extremely common. They are for the most part the result of the tubercular disease, and they increase with the progress of the excavation. They frequently contribute to mask the proper signs of cavities. With care, however, both classes of signs may be discovered. The bronchial sounds may be dry or moist. The dry sounds are most common soon after the commencement of the third stage, the moist at the advanced or concluding part. Dry bronchial sounds frequently become developed, and replace moist ones, when a cavity is becoming obsolete, passive, or contracted.

The tubular constrictive sounds of the primary and secondary bronchi, are not uncommonly heard in the third or cavity stage of phthisis. They are found in a considerable proportion of cases at the upper part of the sternum, and at the costal cartilages of the two upper ribs; but the interscapular regions are very often their seat also. The sounds may be merely tubular or brazen, or they may be of a snoring sawing character. The tubular brazen character holds more in front and above, and the snoring character behind and below.

These sounds may proceed from both sides of the chest, but in this case they are louder, for the most part, upon the cavity side than upon the other when only one side is the seat of excavation. In many cases the bronchial sounds are heard exclusively upon the diseased side. The condition of the tubes giving out the sound now under consideration is one of hyperæmia, of thickening of the mucous membrane, and of the sub-mucous tissue, occasionally conjoined with a slight degree of spasm of the circular muscular fibres. It is most important, in every example of disease presenting these sounds, to avoid a hasty conclusion that the disease is merely bronchial. In every case careful exploration of the lungs should be made; but it is absolutely necessary, if the physician would avoid placing his patient's welfare and his own character in jeopardy, to institute a narrow and anxious search for pulmonary mischief, more especially when the morbid sounds have been of only some months' duration, and when the patient is suffering from febrile action, and from general deterioration of the health. I have known careful examination result in the discovery of cavities in numerous cases in which bronchitis only had been at first suspected. The search for cavities should be made further from the median line of the body. These sounds, in some cases of cavity, become exceedingly loud below the scapula, and in the lower dorsal regions, and I have known them in some examples lead to grave perplexity. They have for a time succeeded in masking all true and decisive cavernous sound. Yet careful and renewed exploration has succeeded in proving that bronchial disorder was not the only morbid condition present, but that there was another—a tubercular cavity, which in all probability was the primary cause of the bronchial affection. In young hysterical females these sounds are particularly liable to satisfy the medical attendant, that the case is only one of bronchitis, and to lead him to omit that renewed and careful exploration that alone can suffice to detect cavernous sounds, and to prove the merely secondary character of the bronchial affection with its loud and noisy accompaniments. These bronchial sounds thus accompanying cavities are always associated with some of the decisive signs of cavities, such as cavernous respiration and voice, dull percussion, &c.; but it is to be remembered that in some examples of cavities, the signs are but faintly developed, and again, that bronchitis may occur in persons who have naturally a depressed chest and dullish percussion. In doubtful cases of this class, every reasonable mode of investigation, and every aid in exploration, should be adopted. I have at this time in the "Rose" ward, a middle-aged female (Albert) whose cavity signs are greatly masked by dry sonorous and constrictive tubular sounds. Dull percussion, great deficiency of respiration, and superficial waving impulse of the heart under the clavicle of the right side, are the chief signs which lead me to infer a cavity, though distinct cavernous respiration cannot be made out. Snoring noises prevail over the whole chest.

Moist bronchial sounds are developed at one time or another in every example of phthisis that reaches to the cavity or third stage. In many cases the mucous râle, as the chief bronchial moist sound has been called, which is heard in the third stage of phthisis, is simply a continuation or an exaggeration of the humid crackle sign, which held in second stage, and more rarely, and to a less extent, in the first. The liquid bronchial crepitation and bubbling in the third stage corresponds with the humid crackle of the second. It varies more in size, and has a wider range than the humid crackle. It takes place in the chief bronchi, and in all but the terminal tubes. The size of the bubbles, judging as we do from the properties of the sound, varies very considerably, but they appear generally to be of the dimensions of a pea or a swan shot. In quiet, comparatively silent cavity cases, the number of explosions is small, and they take place individually, and one after another. In other cases, again, the sound indicates the simultaneous explosion of very many bubbles in tubes. In some cases, the whole inspiration period, and the expiration period, are occupied with the sound of numerous explosions; many occurring at a time.

In some old cases of cavities, the entire base of the cavity lung, and even the base of the opposite and non-cavity lung, are the seat of continuous bronchial liquid sounds. These liquid sounds, unlike those at the apex, in the softening or second or cavernulous stage, do not usually appear to be very near the surface of the chest, or as happens, in some second stage cases, as it were, immediately under the integument.

These liquid sounds in the third stage of phthisis, are heard at various localities in respect of the cavity. When cavities are very recent, and situated at the apex, these bronchial sounds are often heard almost exclusively in the immediate neighbourhood of the excavation, and in the course of the larger bronchi, as they proceed towards the median line of the body. They may be heard over the cavity and around it. At the posterior part of the chest, between the inner edge of the scapula and the spine, they are common. Liquid bronchial sounds are very common at the base in advanced cases of phthisis in the third stage. When the general health is greatly broken, and the patient is about to sink, particularly if there be present an œdematous state of the feet, the liquid sounds are generally heard at both bases, even though a cavity may be present on one side of the chest only. As disease advances, and the patient is about to die, some moderate amount of liquid bronchial sound may likewise be made out at the apex of the side which had hitherto been the seat of healthy sounds only. That the loud, liquid bronchial sounds may for a considerable time successfully mask a cavity, is well shown by a case now in the Richmond ward. A man (Bradley), about thirty, had large liquid bronchial sounds only at first. Now greatly improved, the patient's sounds are less loud, and cavernous bruits are to be heard.

A fine form of liquid bronchial sound, smaller than that I have just described, is liable to take place in cases of advanced cavities. This is a sound of bubble explosion larger than the fine crepitation of pneumonia. The sound suggests the size of the bubbles to be about that of small shot. This is usually spread over the chest, occurring much at the posterior aspect of the base of the thorax. It is sometimes confined to the cavity side, but it is often found upon the side free from such an anatomical condition. It occurs for the most part suddenly, and is accompanied with acute suffering and symptoms which suggest the presence of inflammatory action of the finer tubes. When the lung has been long condensed by repeated attacks of pneumonia, this sound is heard in those parts which are yet comparatively free from condensation. The old condensation has obliterated the channels which are essential to the production of the sound. Thus we have in some cases only large liquid crepitation in the old diseased and condensed structure, and the finer sounds in the comparatively unaltered structure of the lung.

The important fact, that the signs of bronchial affections may mask those of pulmonary consumption, has been noticed by different physicians, but this subject has received special attention from Dr. Hughes Bennett of Edinburgh, in his book on this malady.

Laryngeal and tracheal sounds are of very common occurrence in the cavity stage of phthisis. They are worthy of study in themselves, and on account of their bearing in respect of the original malady upon which they depend.

A common tracheal sound is a clicking or ticking noise, which proceeds from the trachea, and less frequently from the larynx. It seems to proceed, in many cases, from the lower part of the trachea, just where it divides. The sound is remarkable for its regularity as to period. It keeps time remarkably well: occurring regularly every few seconds. It is such a sound as is produced by the explosion of a bubble the size of a large shot. It is frequently the source of great annoyance to the patient, filling his ear all day long, and constantly calling his reluctant attention to his malady. This ticking sound is heard by bystanders, coming through the patient's mouth, and conveyed through the open air. A stethoscope applied over the trachea, conveys it better to the ear. This sign in the case of a patient suffering from cough, whose health is deteriorating, is an ominous sound. In a very large proportion of cases in which I have heard this sound, as the patient for the first time has detailed his history, I have found either decided softening or excavation, the latter being the more frequent condition of the two. This laryngeal and tracheal sound is analogous to the commencing humid crepitation or crackle of the second stage. It proceeds from the same mechanical cause, viz., the rupture of a bubble about the size of a swan shot or a pea, the liquor entering into its composition, judging from the sound, the slowness of its production, and the gravity of its note, being rather thick or tenacious.

Laryngeal constriction, and, so to speak, narrow fissure blowing sounds, are by no means uncommon in the third stage of phthisis. In one out of about fifty of good sized cavity cases, this character of sound is heard. The air is drawn through the larynx with difficulty, and the patient seems always more or less, as if about to be suffocated. This noisy constriction breathing sound proceeds from partial occlusion of the larynx, dependent upon inflammatory changes connected with the disease in the lung, or with morbid action set up in the larynx by the same constitutional habit which induced the pulmonary mischief. The sound is heard through the air, but on listening to the chest, so strong is it there, that other respiratory sounds, normal as well as abnormal, are more or less marked. The blowing of caverns, when gentle, may be masked by this sound, especially if unaccompanied by moist sounds. Care, however, will generally discover some cavernous sound, which will prove decisive of the case. It is very important to avoid mistaking the tubular laryngeal sounds which are caried down into the thorax, for the sounds of cavities, and it is of equal importance to avoid the error of regarding pulmonary excavation conjoined with laryngeal disease, as laryngeal disease only. The blowing of caverns may generally be made out and distinguished by the presence of one or other of the dry or moist cavernous sounds. Little assistance is obtained by trying the voice with the view of producing pectoriloquy, for the voice in such cases is generally extremely weak, whispering or hoarse, and incapable of reaching the suspected seat of cavity with sufficient force.

The fine crepitation of pneumonia which we have already referred to as liable to accompany the signs of phthisis in its first and second stages, occurs frequently in the third stage. In very few examples of cavities at all far advanced, has this sign failed to appear at one time or another. With scarcely an exception, I find such cases as are here referred to, and which came under my care in the wards of the Hospital for Consumption, either presenting the actual sign, or that solidification and contraction which could not have occurred without its having been present at some antecedent period, During the sojourn of the patients in this institution, it is extremely common for them to suffer from what has been called intercurrent pneumonia, and in many of these patients, the fine crepitation of the disease is made out. Many come into the hospital with this sign, and those suffer most in this way who have been neglected, who have had few of the comforts of life, house shelter, or the warmth of suitable clothing. The season of the year in which this sign manifests itself most is winter. The cold of this season exercises a very marked influence on its frequency and severity.

During last winter I had numerous patients with this sign, but during the present summer (1860), though a very temperate one, I have seldom heard this sound. This sign may be very moderately developed, and yet inflammatory action may be extensive and severe, for this reason, that the vesicular structure of the lung is very frequently to a large extent obliterated by previous inflammation, and by congestion and tubercular deposit, and this structure we know is essential to the production of fine crepitation, such as we now treat of.

The seat of this sign is often around the site of the cavity, but when this is placed in the apex, the crepitation is little developed, the lung structure being generally thoroughly destroyed. It is much more common to find the crepitation sound in the lateral regions, and in the inferior dorsal region. It is often confined to one side, but when the cavity is large, and tubercular deposit is being established, or is softening in the other lung, as is often the case, then the sound is heard on both sides, though more upon the cavity side than upon the other.

CHAP. XXIX.

THIRD STAGE — *continued.*

Pleural membrane Sounds. — Dry membrane Sounds. — Sounds of rough Membranes.—Sounds of hardened Membranes.—Friction Sounds of Cavities.

PLEURAL membrane sounds, there is every reason to believe, are developed in almost every example of phthisis in the third or cavity stage. It is probable, however, that the finer ones are well distinguished more frequently in the first and second stages than in the third, though it is in the last that pleural friction sounds are most constantly produced. In the early part of the disease, the abnormal lung sounds are by no means very loud, and they fail to mask pleural sounds, faint though they be. On the other hand, in the third stage, there is generally so much cavernous, cavernulous, and liquid crepitation bruits, that the pleural membrane sounds are masked or so mixed up with other sounds that it is difficult to individualize them. Moreover, in the third stage, these pleural sounds are not always sought for, the signs proper to cavities, and to other more important conditions, satisfying most practitioners, and indeed depriving them of much of their practical importance. The pleural membrane sounds may be divided into three classes: 1, those proceeding from dry membranes; 2, those proceeding from moderately roughened membranes; and, 3, those arising from hardened and roughened membranes.

The first-named sounds are the same as those which are occasionally heard in the earlier stages of phthisis, and at the very beginning of idiopathic pleurisy, i. e. pleurisy not dependent upon another manifested disease. These sounds are often heard when the patient, having a cavity, complains of sharp pains in his side, and when his breathing is voluntarily restrained and is unusually quickened. With these signs and symptoms, the patient is suffering from hyperæmia of the pleura, or the commencement of inflammation. The chief physical condition giving rise to the sound is an abnormal dryness. The pleura costalis and the pleura pulmonalis are both comparatively dry. The lubricating liquid is reduced in quantity, and it is more tenacious than natural. Friction is thus increased, vibrations sufficiently rapid and strong to induce sound are produced. The sound is not loud, sometimes it is nearly uniform during an inspiration, but it is generally somewhat interrupted. When the sound is uniform, it appears that the membranes slide continuously over each other; but when it is interrupted, the movements are interrupted or arrested, as a finger very moderately moistened is passed in an interrupted manner over a table, now passing on with vibration, and now being arrested by resistance. In the first case, the liquid is less reduced, and less thickened than in the latter, at least so it appears to me. That friction sound may be produced by the absence of a very little fluid, a simple experiment will prove. Wet the forefinger with milk, and gently pass this over the back of the concha of the ear; no sound will be heard; let the other forefinger free from liquid, deal similarly with the other ear, and friction sound will be at once produced, and be distinctly heard. Even a very little increase of the thickness of a liquid will produce friction sound, not heard when the liquid is thinner. The finger freely wetted with milk and passed over the ear, when the milk is still perfectly thin, gives no sound, but if the milk be allowed to thicken and become adhesive, a sound will then be audible. It is extremely probable that in the beginning of pleurisy, or in many quasi-inflammatory or congested states of the pleura, common in phthisis, a like thickening of the serous lubricating fluid takes place, and gives rise to abnormal sounds, which might often be heard were they sought for. These friction sounds last generally for a few days only. I believe they go and come when the secretion alters, which it is very apt to do in advanced cases of phthisis. The presence of such friction sounds, in my opinion, is far from indicating the positive presence of inflammation, and still less the necessity of employing lowering means, quietude and confinement to bed for a few days, generally sufficing to bring them to a conclusion.

The sounds which proceed from soft roughening of the pleura are not unfrequently heard in the third stage of phthisis. They are louder and more interrupted than those just described. They resemble the sounds caused by slowly rubbing two pieces of coarse cloth together. This sign is heard most frequently in the lateral regions and under the scapula, and on one side only. It has been heard in about one in fifty of my cavity cases at the hospital. It is heard in nearly every example of pleurisy terminating in empyema, but departing, it is true, when full effusion has taken place, it may be to return again when this is absorbed. The anatomical condition is a roughened irregularly flocculent and opaque character of the pleura, with an obscure reddish tint; flakes of white or grey soft light fibrinous deposit, or of pus, are seen upon the membrane. The seats of these anatomical conditions are the same as the seats of the sounds. The sounds which proceed from these anatomical states are always preceded in acute cases, for a very short time only, by those of the first class, of which they are the further development. Such sounds in general last some days, then entirely disappear either for ever or to return again after a time. They disappear altogether when adhesion takes place at once, which is seldom, this being usually prevented by serous or sero-purulent liquid, separating the two opposed membranes. The sounds return when effusion having taken place and having prevented adhesion, the separating liquid is absorbed and the opposed membranes are brought into contact once more. It is now that the sounds again become audible. When they are heard for the second time, it is usually only for a very few days, adhesion now taking place. This form of pleural friction sound is sometimes supposed to exist when sonorous rhonchus only is present with some vibration, but careful listening will always prevent this error. These sounds are often mixed together, and it is very common for the friction sounds and sonorous rhonchus to be conjoined with moist crepitation, large and small. I have found these loud friction sounds to be continuous during the whole respiratory period, acknowledging no complete interruption, but owning to a remission more or less slight during the latter part of expiration and the period between the end of expiration and the beginning of inspiration. This form of sound is of more diagnostic and therapeutic import than the preceding. When established, it indicates either the advent of acute severe pleurisy, or which is not of less interest, the subsidence of the disease and the absorption of the liquid of empyema. The increase of dulness and acute and sudden symptoms hold at the first epoch; the depression of the line of dulness on percussion, the re-establishment of respiration, the reduction of the dimensions of the side, &c., indicate the latter condition.

The third kind of pleural membrane friction sound is loud and coarse, and resembles that produced by rubbing the finger over dry coarse leather. It is seldom heard in phthisis. I have met with it not more than twice in this disease. It occurs when the roughened pleura, rendered so by the presence of irregular masses of hardened fibrin, has assumed a cartilaginous consistence, and has remained free from complete adhesion. It has been heard by me only at the posterior and lower parts of the chest, where the lung has the greatest motion. This sound is heard both during inspiration and expiration. It is always accompanied by undue fremitus of the walls of the chest.

PULMONARY-COSTAL FRICTION SOUNDS.—Besides these strictly pleural sounds, it is desirable to mention that friction sounds, in which the pleura are in some measure involved, are induced by the lung structure itself. The lung has lost its lightness and softness, it presents numerous rounded projecting tubercles on its pleural surface, or it is a hard, thickened irregular cavity-wall mass. This lung, covered with pleura, rubs against the pleuro-costalis and the ribs, and a loudish friction sound is induced. At the upper part of the thorax, this friction sound is seldom heard, for the reason that the motion there is moderate and soon admits of adhesion taking place. It is at the lower and posterior parts of the chest that this form of sound, like the last, is generally heard. These pulmonary-costal friction sounds are often ultimately conjoined with soft friction sounds of fresh exudation, for inflammation of the pleura is ever disposed to set in, and cause exudation. By means of adhesions, they often become lost after having been developed some days or weeks.

FRICTION SOUNDS OF CAVITIES. — Sounds of creaking and coarse crumpling are commonly heard to proceed from the friction upon themselves of the various parts of a cavity mass. During the inflation of the cavity and the expulsion of air from it, the cavity walls are moved upon themselves, and they emit the coarse sounds alluded to. I hear such sounds constantly in my cavity patients at the hospital. The favourite seat of them, as might be expected, is the subclavicular region, but I have often heard them above the clavicle. The noise, for it is a loud coarse sound, is like the sound of leather bent backwards and forwards upon itself. It has sometimes partaken much of the character of wood creaking.

CHAP. XXX.

THIRD STAGE—*continued.*

Reduced respiration Sounds at Base. — Abolition of respiration Sounds at Base. — Puerile Respiration. — Increased Respiration of Base. — Excessive Loudness at Base.

REDUCTION OF RESPIRATION AT THE BASE OF THE CAVITY LUNG.— This sign has been made out in about one half of the examples of phthisis in the third stage which have come under my care. The respiratory sound is less full and less fine than natural. It is often conjoined with an occasional sibilus or sonorous rhonchus. The voice is usually reduced, occasionally it is louder than natural, and accompanied with more than the usual fremitus. The respiratory sounds are not remote. The difference between the full respiration of the healthy base, and the defective respiration of the unhealthy one, is made out pretty distinctly with the wooden stethoscope, but it is with the differential instrument only that the deficiency is rendered a very striking sign. When the two limbs of the instrument are placed respectively on the two bases in such cases, it is usual to have a full sound perceived through the ear connected with the healthy part, and total sensorial silence in the ear connected with the unhealthy part.

This deficiency of respiration sound of the base of the lung is due to the presence, in some rare cases, of simple hepatization, the result of inflammation provoked by the constant irritation of a cavity above; in others, and these are more common, it is due to a conjoint state of hepatization, crude tubercles, more or less numerous, and more or less advanced, and to very considerable congestion, and sanguineous and serous infiltration. This reduction of respiration in the third stage of phthisis is a progressive sign. Once commenced, it remains, or more or less rapidly increases until nothing is heard except a very little coarse bronchial respiration sound, or an occasional sibilus or sonorous rhonchus. Its course is slow, and unattended for the most part with that sudden development and almost as sudden declension observed in respect of the abolition or reduction of respiration due to empyema. The gradual development also greatly differs from the instantaneous abolition of ordinary respiration sounds, in some examples of pneumothorax, attendant upon phthisis.

THE ABOLITION OF RESPIRATION SOUNDS.—The total abolition of respiration sounds at some parts, and occasionally over almost the whole of one side of the chest, takes place when copious effusion is poured into the cavity of the pleura. This effusion depending upon inflammation occasionally takes place in the third or cavity stage of phthisis, as a direct consequence of that disease, and it is more commonly observed in this stage than in either of the two preceding ones. The abolition of respiration also is due, in a very few examples of phthisis at this period, to serous effusion depending upon an anæmic state, or a dropsy-forming condition of the blood, often dependent upon co-existent disease of the kidney and albuminuria, now and then combined with tubercle in that organ. It is also by no means unfrequently due to a very different condition, viz., the interposition of atmospheric air between the lungs and the thoracic walls causing collapse and compression of the lung. But this condition of air in the cavity of the pleura depending upon perforation I have decided to treat as constituting a later and concluding stage of phthisis.

Another cause of the abolition of respiration sounds in the third stage of phthisis is occasionally found in the enlarged and fatty degenerated liver which occasionally accompanies pulmonary tuberculosis. The liver occasionally, too, presents the lardaceous character. Total abolition in consequence of the enlarged liver is found to exist on the right side of the chest only. No respiratory or vocal sound whatever is heard in some cases below the level of the nipple. The lung is pushed up beyond that level, and its place is occupied by the encroaching liver. During the last five years I have noted this state of things, or an approach to it, in some half dozen post-mortem examinations made at the Hospital for Consumption. A man named John Carr died in the hospital in 1856 under Dr. Cotton. The apices of both lungs were excavated. The liver weighed 12¾lbs. A soldier named John Mann, also under the care of Dr. Cotton, died in 1857, and presented a very large encroaching liver. It weighed 11lbs.1oz. Both the lungs at their apices were excavated. Such cases are generally associated with jaundice, and the liver is felt large in the abdomen.

The abolition of respiration sounds due to the sero-purulent liquid of empyema, begins at the bottom of the chest, and slowly and gradually proceeds upwards, i. e. when the patient occupies the erect posture. It is common for it to reach to the angle of the scapula or a little above it, and to stop there. It sometimes rises higher, and I have in several examples, perhaps half a dozen, found this abolition as high as the level of the second rib in front. The abolition ascends gradually and equally, perhaps half or a whole inch, or even more in the twenty-four hours. It is accompanied with very considerable dyspnœa, sometimes very great dyspnœa, and occasionally with only moderate distress, the dyspnœa in general being in proportion to the extent and rapidity of accession of the abolition of respiration sounds. I have seen much distress from little effusion, and in a few cases I have heard the patient say, that his breathing was easy when one side of the chest has presented no respiration sound, except above the second rib. The suddenness or slowness of the effusion, and the healthy or unhealthy state of the opposite lung, have explained these anomalies.

The abolition of respiration sound in the case of the empyema of phthisis in the third stage is confined to one side: at least I have always found it so.

The percussion under these circumstances is absolutely dull. The voice at the clavicle is usually loud or cavernous; at the base it is absent. When the effusion has reached the angle of the scapula the voice becomes ægophonic, a character whose singular properties and mechanism I have already described. When the abolition of respiratory sound ascends to the spine of the scapula, ægophony is lost.

The dimensions of the chest increase: the semi-diameter increases, and the excess may reach from one to two inches. The intercostal spaces bulge in an undue manner. The side remains little affected in shape and movement at different periods or stages of the respiratory acts. When the patient at an early period of the abolition of sound is placed upon his abdomen, some sound is occasionally heard posteriorly, the liquid falling to the anterior and now lower part of the chest.

After a time abolition of sound from empyema is marked by remarkable changes. The line of absolute dulness falls, ægophony returns, and as absorption of the liquid proceeds finally disappears.

In a remarkable example of the abolition of respiration due to empyema and connected with pulmonary tuberculosis (Bird), I believe, in the third stage, a fistulous opening existed at the right subclavicular region near the sternum, which evacuated much fetid pus and respiratory air. The patient also expectorated much of the same liquid. Humid crepitation had been observed some time, and latterly liquid cavernulous sounds became audible under the right clavicle at its humeral extremity. Absolute dulness prevailed from the base close up to the clavicle. This patient died. I have in other examples of phthisis found fistulous openings discharging pus from the pleural cavity, but they have been under the fifth rib.

The abolition of sound due to serous effusion is slow in its development. It is usually very partial, and confined to the very base of the chest. It is commonly found on both sides of the thorax. It seldom rises high. There may be bronchophony, but ægophony is seldom heard, if I may decide by my own experience. The countenance and white colour of the skin, the œdematous feet, &c., usually point out the true nature of this form of abolition of respiration sounds.

PUERILE OR AUGMENTED RESPIRATION OF THE LUNG ON THE HEALTHY SIDE OF THE CAVITY LUNG. — This is a very common occurrence. It is most observed at the upper parts of the side. It serves by contrast to mark well the deficiency of the opposite side. In such cases the expiration is usually somewhat prolonged.

INCREASE OF RESPIRATION AT BASE OF DISEASED LUNG. — This condition I have not unfrequently noted in cavity cases. The loudness and fulness have been such as to eclipse the healthy sounds of the healthy base, when I have employed the differential stethoscope. In such cases the base is compensating by excessive action for the deficiency of its apex.

Excessive loudness, too, of the respiration sounds of the base of the unhealthy lung is occasionally established, and after the manner noticed above eclipses the weaker sound of the healthy base. This loudness depends upon the resisted respiration due to the presence of crude tubercle. It is analogous to the harsh and loud respiration sounds of the first stage of the disease. The circles express these acoustic results. The black circle denotes sound heard, the dotted circle sensorial silence.

Unhealthy side.

Healthy side.

CHAP. XXXI.

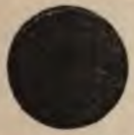
THIRD STAGE—*continued.*

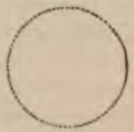
Auscultation of Heart and great Vessels.—Loudness and Nearness of Sounds at upper Interspaces.—Arterial Blowing from Pressure, influenced by respiratory Acts.—Arterial Murmurs from intrinsic Disease.—Adventitious Heart Sounds: pure and mixed.—Venous Murmur.

The auscultation of the heart and great vessels, in the third stage of phthisis, is very important, and reveals in a very large number of cases abnormal signs very useful in the diagnosis of this disease. Even when these signs are of little value in a diagnostic point of view, or are superfluous, from the decisive character of other signs, it is very important to note them; for such anomalies, as they really are, prove highly interesting, and present points for study which may afford a reflected light upon the pathology of these parts and of various diseases. To omit the remarkable alterations in the locale, impulse and sounds of the heart, and the arterial and venous sounds which are sometimes established, would be to write the signs of phthisis in an exceedingly imperfect manner; and for the physician to pass them over unnoticed and unthought of, would argue a style of treatment furnishing little accurate information.

Although the auscultatory signs of the heart, &c., compared with percussion, &c., are less valuable, I prefer treating of them in this place, because I shall thus be enabled to conclude the subject of auscultation in this stage; and by so doing I am enabled to keep together all the auscultation signs of the period, an arrangement which will be convenient for reference to this branch of inquiry.

One of the most remarkable signs connected with the heart's sounds, in the third stage of phthisis, is a striking loudness and nearness to the ear, under the clavicle. The heart's sounds reach the ear, as if that organ lay, which in many cases it really does, under the second intercostal space and the second rib, and as if the whole, or nearly the whole, lung structure which formerly and in health covered it were destroyed and obliterated. The point of greatest loudness is changed; the greatest intensity is translated; the loudness is greater at the second interspace than it is at the fifth. When the cavity is situated on the left side, this sign is most developed; when the cavity is situated on the right side, the sounds of the heart are still greatly augmented, but the increase is less than when the disease is upon the left side. I have often found the sounds of the heart upon the right side at the second interspace more loud than at the fifth interspace on the left side, and under the nipple: this occurs invariably when, by reason of contracting adhesions, the heart, as is often the case, is drawn upwards and to the right. So decidedly are the sounds of the heart louder at the second and third interspaces, the cavity being on the left side, than at the fifth interspace, the point of greatest normal intensity, that when the two limbs of the differential stethoscope are placed upon these points respectively, the sounds are heard at the first-named places only, and not at all at the point of normal greatest intensity. The acoustic circles will serve to illustrate these facts. The black represents sound, the blank silence.


Second Interspace.


Fifth Interspace.

The abnormally-heightened intensity of heart-sounds at the parts indicated, due to the presence of a cavity, is in character somewhat different from the increased loudness of solidification, whether that be of hepatization, tubercle, or cancer. The loudness of cavity has a character of nearness and directness; the loudness of solidification has a character of comparative distance, and of transmission through a solid conductor that also intervenes. The loudness of solidification is not associated with a cardiac impulse that may be seen and felt; while the loudness of a cavity is almost constantly associated with an impulse that may be felt and seen at the second or third interspaces, or at both. The heart is felt beating immediately under the fingers; the impulse is very great in some cases of large cavity, and the integuments may be seen to swell and fall with every beat of the pulse at the wrist. A waving of the integuments may be observed in many cases, and this is synchronous with the systole and diastole of the heart. The auricles are beating immediately under the integuments. In such examples of loudness, due to cavity, depression of the upper ribs, retraction of the interspaces, and flattening of the upper front of the thorax upon one side, are usually present. A sense of fluctuation holds.

The explanation of the loudness of the heart's sounds is sufficiently obvious. The phenomenon is due to two causes, viz., first, the increased proximity of the sounding body, the heart, to the ear, by the destruction of the lung, which in health intervenes; and, second, the increased activity of the heart under the local excitement and the general systemic irritation. The first-named cause is the chief source of this sign. The second is very subsidiary, and indeed, in some cases, when the loudness has been extreme, has been altogether absent. When the heart is very placid, the loudness of which we speak may be very great notwithstanding.

ARTERIAL BLOWING SOUNDS FROM PRESSURE. — Arterial sounds of a blowing character, usually called murmurs, are very common in the third stage of phthisis; and though of little value in a diagnostic point of view, quoad phthisis, are yet deserving of every attention. It will seldom happen in the third stage of phthisis that the other signs of this state will be so few and so feeble in their testimony, that aid in respect of diagnosis on the part of arterial murmurs or blowing sounds can avail much; yet a knowledge of them in this state will enlarge our information of the history of the sounds of the great vessels, and of the influence of phthisis in respect of them. A knowledge that these murmurs are commonly produced by the excavated lung and the descending thoracic walls may prevent the erroneous conclusion of these arterial or cardiac diseases being present when none really exists.

The number of cases of phthisis in the third stage, in which I have heard arterial murmur or blowing, is very considerable. The proportion of examples of this blowing will depend much upon the class of cases which is submitted to numerical examination. If we take examples of phthisis which have attained to the third stage after a very short period, in which the cavities are small and the surrounding pulmonary tissue is soft and œdematous, and are situated upon the right side, we shall have a very small percentage of instances of arterial murmur or blowing. If, on the other hand, we take examples of old phthisis, which have attained to the third stage slowly, or, still better, if we take cases on the left side of the chest, marked by thin hard walls and in-drawn ribs and intercostal spaces, we shall have the percentage of examples very considerable. In the first class of cases we may not have above 1 per cent., while in the latter we shall have as high a percentage as 20; i. e. twenty examples of blowing, well marked, out of 100 examples of phthisis, in the stage and with the conditions above denoted.

At the present time (January 24th, 1861) I have a very fine example of this sign in the hospital. James Stockbridge, æt. 34, servant, Paget Ward, is greatly exhausted, consequent upon excavation of both lungs. A loud systolic murmur is heard at the second left interspace. As the ribs fall in expiration, the sound becomes louder. To each expiration two or three short rushing sounds are heard in succession. The patient is very pallid and anæmic.

Arterial blowing sound is much affected by the side upon which excavation has taken place. For one instance of arterial blowing with which I have met on the right side, I have found about ten on the left.

The area of arterial blowing dependent upon tubercular cavities, is well defined. It seldom or never descends below the level of the upper border of the third rib. When on the left side, it extends from the left border of the sternum at this level, an inch or more outwards, rapidly becoming weaker; it usually embraces the whole of the first and second interspaces from the sternum, for the space of an inch externally. In not a few examples, the sound is heard to rise an inch in the neck, in the course of the carotid artery. In some few examples I have traced it along the whole course of the superior and inferior borders of the clavicle. In some cases the blowing is heard exclusively at the second interspace; in others, again, exclusively at the first interspace. When the blowing is situated at the clavicle, and in the neck, it frequently assumes a harsh character. The blowing at the first and second interspaces, particularly the latter, is more gentle, breezy, easily overlooked, and often requiring great attention to discover it. I have once or twice heard a sound of this character along the spine, between the scapulæ, as if proceeding from the thoracic aorta. It has been associated with blowing at the first left interspace.

When blowing occurs on the right side of the chest, from the presence of a cavity, the sound is heard at the sternal extremity of the first interspace. I have in a few examples heard a blowing arterial sound along the clavicle both above and below.

These blowing sounds are systolic; there is a portion of the sound to correspond with every contraction of the ventricles of the heart.

The arterial blowing of the cavity stage of phthisis is much influenced by the respiratory acts. In some few examples, the sound is continuous and uniform during the whole respiratory period, but in most examples it varies in intensity with the different stages of respiration, and in not a few I have found it intermit at one part of the respiratory function. When the sound has not been continuous and equal, it has generally risen in intensity with the act of expiration, reaching its climax at the very end of this period, and during the short pause between the end of expiration and the beginning of inspiration. In a few examples I have noted that the blowing has become stronger when a forced inspiration has been made, and the chest has remained immovable for a few instants. In this way I have been enabled to render arterial blowing audible, when under other circumstances it could not be heard. I have met with comparatively few examples of arterial blowing in which the sound has been confined to the period of inspiration, or in which this part of the respiratory act has intensified the sound.

Increased action of the heart produced by exercise, or by other temporary excitement, will often succeed in intensifying these arterial sounds. A sound which has not been appreciable after a patient has sat some time, is sometimes restored by causing him to walk quickly through the room. I have not unfrequently found that an arterial blowing which had been distinctly heard on first examining a patient when he has just come in and been somewhat agitated, has, after a time, when I have wished to hear it again, been altogether inaudible. This occurrence has sometimes caused me some embarrassment. At first I used to doubt the accuracy of my first observation, but I soon learned not to attach much weight to the disappearance, so to speak, of the sound during periods of quietude. I have sometimes been somewhat rather awkwardly placed when having heard a distinct arterial blowing, I have requested another physician to examine the patient, and when the auscultator, having taken a period of quietude for his examination, has been unable to make out the sign.

Arterial blowing sounds sometimes acquire an amphoric character. I have observed this in some three or four examples. The sound is heard as if the arterial blowing passed through an empty chamber with vibrating and sound-reflecting walls. This is really the case. This amphoric character is perceived only in those cases in which amphoric cavity respiration and voice sounds are heard. The cracked-pot or money-jingle sound, on percussion, is usually associated with it.

When the blowing arterial sound is intensified by holding the breath, this seems to be produced by the pulmonary artery and right ventricle being unduly filled with blood, and from the right side of the heart making a more than usually strong effort to propel its contents.

When the arterial blowing of the cavity stage of phthisis is enfeebled by inspiration, it appears to depend upon the pressure of the hard walls of the cavity and the pressure of the thoracic walls being obviated for the time. Air is admitted into the chamber, and air is less resisting than these solid parts. The anæmic state of the body, i.e. a thin condition of the blood, from poverty of red particles, seems to favour the production of these arterial sounds.

These sounds have been heard by me in both sexes, I believe pretty equally. The finest example of the amphoric arterial blowing I have met with, occurred in a man (Watson) about forty years of age. The best example of arterial blowing heightened during expiration I have had is still under observation, and is found in a woman about thirty-five years of age. In children I have noted it, but more rarely than in adults.

The seat of these arterial blowing sounds is the pulmonary artery, the left side of the arch of the aorta, where it gives off the carotid and the subclavian arteries, and these latter arteries themselves at their origin, on the left, and the innominata on the right side. The pulmonary artery, I believe, is by far the most frequent seat of these sounds. I come to this conclusion because, in most examples of this sign, the blowing is loudest at the second interspace, close to the sternum, this being near the seat of the origin of this vessel; and in many cases it is confined to that part, failing to be heard higher up in the course of the carotid or subclavian artery. The lung lies over the pulmonary artery, and is here the very frequent seat of cavity and of hard cavity walls.

The left border of the arch of the aorta is doubtless the occasional seat of this sound. When this is the case, the sound will be loud at the first space, and in the course of both the carotid and the subclavian. I have once or twice, as I before said, heard a murmur, or blowing between the scapulæ, as if it were proceeding from the descending thoracic aorta. The left carotid and subclavian arteries are, in health, covered at their origin by the lung, and the contracted hard tissue of cavities at the apex come in contact with them in the third stage of phthisis.

The innominata is occasionally the seat of this blowing sound, just as it passes up to the right clavicle in an oblique direction, at the sternal extremity of the first right interspace, the pulmonary disease being on the right side.

The blowing arterial sounds of the third stage of phthisis are produced by pressure upon the arteries which have been named. The pressure is produced by the hard walls of cavities, by the hard fibrous exudation, by the hard thoracic walls now brought abnormally into almost direct contact with these blood-vessels, the soft pad of healthy lung being now removed, and in some cases in this stage, as in the two preceding ones, by enlarged bronchial glands. When the sound proceeds from the pressure of the anterior thoracic walls, dragged inwards by contracting fibrous exudation, the pressure will be somewhat mitigated during the period of the elevation of inspiration, and an intermission or an abatement of the blowing sound may be expected to take place. This abatement is exactly what occurs in practice, as I have already stated.

Blowing, or hissing, or rasping arterial murmurs, occur in the third stage of phthisis from other causes than pressure, viz., from internal disease and obstructive or defective valvular conditions. It has been said, too, that a subclavian murmur may occur from elevation of the first rib in inspiration, causing pressure upon that artery; and it is obvious, if this ever really do occur, which, in my opinion, is doubtful, it may take place in the third stage of phthisis.

The aorta and the pulmonary artery frequently take on diseased action in the third stage of phthisis. Some fifty per cent. of bodies dead of phthisis in the third stage, present the aorta in a moderately diseased state. A much smaller percentage shows disease of the pulmonary artery. It is only in a small proportion of cases of disease of these vessels dependent upon phthisis, that abnormal alterations in the sounds of these parts take place, or that new sounds are induced. The scattered points of fibrous exudation, more or less small, which constitute by far the larger number of the alterations of structure observed, do not sensibly modify the sounds of these vessels, nor do they induce adventitious sounds. But when, by reason of inflammation of the valves, signs of which I have observed in several bodies after death by phthisis in the third stage, the sounds are altered. Together with the exudation of lymph, and attachments subsisting between the valves, there has generally been conjoined some constriction of the arterial orifices. This amount of disease has sufficed to produce adventitious blowing sounds, for the most part only systolic, but in a very few cases, diastolic also. It has happened that the blowing sounds from alteration dependent upon phthisis have, like other alterations, held much more with the aorta than with the pulmonary artery, probably in the ratio of ten to one.

The blowing arterial sounds of disease of the vessels, generally, in some degree or other, inflammatory, have been more harsh than the sounds produced by mere pressure. The heart's action has also been much more disturbed, and the impulse has been more diffused, and more uniformly and persistently increased.

When the aorta is the seat of disease, as is usual, the sounds are heard at the sternum, on the level of the second rib, and right and left of it, as strong on the right side as on the left, and sometimes stronger. The range to the right is greater than to the left. When the pulmonary artery is the seat of the disease and of the murmur, the sound is louder to the left of the sternum, and may not be heard at all on the right. The sound, too, is generally but not always weaker than that of the aorta.

When the sounds are double, the diastolic blowing may be heard as low as the left nipple, or even lower, if the aorta be the seat of the disease. When the pulmonary artery is the diseased part, the diastolic murmur may descend as low as the lower extremity of the sternum, it is very prolonged, and may be inaudible at the left nipple.

I have in the hospital, at present, a patient who has a systolic pulmonary artery murmur, heard only to the left of the sternum at the second interspace, and a diastolic aorta murmur heard at the sternum and a little to the right; it is exceedingly long and silvery. The patient, a man about forty years of age, has a large tubercular cavity on the left side, of very considerable standing.

ADVENTITIOUS HEART SOUNDS.—Adventitious heart sounds may be divided into two groups: first, into pure heart sounds; and, second, into mixed heart sounds. The first include the friction pericardial bruits and the endocardial murmurs; the second comprise sounds mainly due to movements of the heart, but to the production of which the contact of lung, in a diseased state, with the heart is essential.

The pericardial sounds proceed, in most cases, from the presence of lymph upon the pericardium. They are the same as occur in the second stage of the disease, which have been already described. They occur more frequently in the third stage than in the second, and much more frequently than in the first. They are loud and bold during the systolic and the diastolic period. They also proceed, but more rarely, from the patches of fat and fibrin, usually the size of a sixpence, under the adherent pericardium, raising this membrane, which, however, retains its smooth surface.

When the sounds proceed from these white patches, the bruit is generally single, and partakes much of the character of a simple, gentle, limited rubbing, synchronous with the systole of the heart. It is generally very circumscribed in its area. The sounds of the heart proceeding from exuded lymph—of general inflammation, are diffused over the whole site of the heart, but they are more developed at the base than at the apex. The sounds of the white patches are heard near the apex. The usually very rapid action of the heart in the third stage of phthisis serves to intensify these sounds. The patches giving rise to this friction sound, though no doubt frequently present prior to the development of phthisis, are, doubtless, a common effect of the great and neighbouring irritation, and of the great contamination of the blood ruling in the third stage of phthisis.

Abnormal sounds, proceeding from the interior of the heart, are by no means uncommonly the result of phthisis in the third stage. They proceed from various causes, viz., the exudations of inflammation of the mitral and tricuspid valves, and of the orifices which they guard, and from the formation of clots and fibrinous pedunculated hanging tumours in the ventricles. These formations are very common in phthisis.

The clots of blood are very commonly found in the ventricles, particularly in the right, and when they have been present some time before death, and have mechanically intercepted the current of blood, there is reason to believe, have given rise to the murmurs which have been heard before death. If murmurs are less common than these clots, it is probably because these bodies have not been much in the current of the blood, and because the action of the heart has failed. I cannot doubt that the murmurs which I have occasionally heard at the apex of the heart, in persons in the third stage of phthisis, and in whom no valvular alteration has been discovered, but in whose ventricles white, fibrous, soft tumours, suspended in the ventricle, have been detected, have been due to these adventitious bodies. These growths suspended in the cavity, freely moving about, and attached to the columnæ carneæ and the walls of the ventricles, seem to be well calculated to produce such an impediment to the current of the blood, as to produce a murmur. I have met with these growths some ten times. They have been more commonly seen in the right than in the left ventricle. Some of them I have seen hollowed, and containing corpuscles very much like pus globules. Of their origin I shall speak when I come to treat of the morbid anatomy of phthisis.

The mixed heart sounds are of two kinds. The only kind which has been recognized by the profession, is a rubbing sound produced by the movement of the heart upon the diseased lung. When the part rubbed upon is solid, the sound is merely a rubbing single sound. I have heard it many times. It varies a good deal in character, sometimes it is soft, but it is more commonly harsh, grating, and even rasping. Dr. Theophilus Thompson met with some examples of this sound, to which he gave the title of chisel sound. I remember his showing me a patient of his who presented this sign. When some air is contained in the bronchial tubes, a sonorous cooing sound is produced, synchronous with the heart's movements. The succussion sounds in moist cavities, synchronous with the heart's sounds, have been already noticed as cavern sounds, but they deserve mention again in this place.

The other kind of mixed heart sound is one which has hitherto not been noticed by writers, and possibly it will be thought by some that it has no existence in nature. However, I am convinced that it is occasionally developed. It is a systolic murmur or blowing, proceeding from the auriculo-ventricular orifices, pressed upon, and narrowed by, the contracted walls of cavities, and by the retracted ribs in front of the heart. I have occasionally heard distinct sounds, much the same as the tricuspid and mitral murmurs, when there was little or no other evidence of disease of these parts, and when there has been ample pressure upon the heart, judging from the greatly depressed ribs, and the violent and seemingly constrained action of the heart, to cause some impediment to the passage of the blood through the orifices, and to throw the solid parts into vibrations strong and frequent enough to produce audible sounds or murmurs.

Venous murmurs in the chest I have occasionally heard near the base of the heart in the course of the innominatæ and the superior vena cava, in the cavity stage of phthisis. I have heard it more frequently on the right side close to the sternum, and at the level of the second rib, than upon the left side of the body. It has occurred in anæmic females, and in males previously full blooded, who had recently lost much blood by hæmoptysis.

Upon the whole, this venous murmur is by no means generally to be made out in phthisis, and it cannot be said that this disease tends generally to produce it. It is only under particular circumstances, that phthisis, in any stage, can be said to cause it. These circumstances are those stated above, and a moderate,—a very moderate degree of pressure upon the veins. Great pressure tends rather to prevent murmur. The flow of blood is reduced in force, and the vessel is held so firmly as to oppose vibration. When the pressure of a cavity is such as to distend the veins, we never have murmurs, and it is extremely common for cavities and their adjoining solidified structure to cause venous obstruction. In the distended veins of the neck, so common in the cavity stage, we have an evidence of this. On looking at a patient for the first time, I have frequently been enabled to make a conjecture, as to the side upon which a cavity was situated, from the presence of a distended vein in the neck; and on further examination, this has turned out to be correct. It is therefore not surprising that we seldom meet with venous murmur in the third stage of phthisis, which indeed in many cases tends greatly to the retardation of the venous thoracic circulation. The very fibrinous condition of the blood in the advanced stages of phthisis, from the almost constant presence of inflammatory action, in one part or another, will serve further to explain the infrequency of this sign.

CHAP. XXXII.

THIRD STAGE—*continued.*

Percussion.—Frequency of Alteration.—Varieties: dullish, dull, absolutely dull.—Cracked-pot Sound.—Mechanism.—Table.—Confined to Cavities: various Facts.—Cracked-pot Sound from Percussion over Liver in dead Body.—Clear and Tympanitic Sounds.

In the third or cavity stage of phthisis, the percussion sound of the thorax is almost invariably affected in a sensible degree. It is more generally affected in the third stage than in the second, and much more than in the first. The percentage of cases in which the percussion sound is not modified to a sensible extent is exceedingly small, not higher than two per cent. in my experience. The percussion sound of the third stage differs from the percussion sound of the preceding stages, not only in respect of frequency and numerical proportion, but in other important points. The modification is usually very much more expressed. The dulness is greater; it is often very great, and not uncommonly absolute. It is more diffused in many cases, holding over one entire side from the first rib down to the very base of the lung posteriorly. The extreme dulness of the anterior and superior parts of the thorax sometimes contrasts most strongly with the comparative clearness of the base, and with the full natural resonance of the opposite superior front. The varieties of the percussion sound, in the third stage of phthisis, are more numerous, and, as a whole, much more marked than in either of the other stages that have been already considered. The difference between one kind of percussion sound and another in this stage, i. e. the range of sound, is much greater than in any other stage, including the new stage which I propose to introduce, viz., that of perforation. Take, for example, the almost imperceptible dulness, and compare it with the not unfrequent absolute dulness; take again the not unfrequent absolute dulness, and compare it with the amphoric sound of perforation, i. e. of pneumothorax, or the resonance of conjoined emphysema.

The general prevalence of dulness of percussion sound in the third stage of phthisis will be exhibited by an examination of the patients under my care in the Hospital for Consumption at this moment. The number of my patients in that institution, in the third stage of phthisis (Sept. 4, 1860) is twenty-one; and of this number all, except one, present dull percussion, varying, it is true, in amount, and somewhat in character.

Table showing the percussion sound in twenty-one cavity cases:—

Short duration.	Dullish.	Decidedly dull.	Absolute or empyema dulness.
1	3	16	1

The varieties of percussion sound in phthisis, in the third stage, are numerous.

It may be safely affirmed that, in scarcely any case of phthisis in the third stage, is the percussion found to be *strictly* natural. Of course there are ears which cannot appreciate nice differences of sound, and this proposition will therefore find objectors, but their number will be small and their objection will be immaterial.

Before percussion becomes what is usually styled dull, it often acquires a character of shortness. It becomes short in duration before it becomes positively dull, as I previously stated. It is very important to know and attend to this fact; for in a proportion of examples of phthisis, by no means very small, even in the third or cavity stage, the percussion does not strike the mind of the physician as decidedly and unequivocally dull, though quasi dullish. The chief characteristic of this percussion sound is the extreme and marked shortness of its duration. Another feature is one which it shares in common with other varieties of dull sound, viz., the great and abnormal limitation of the vibration area, of which something has been already said under the head of the first stage signs. In almost, or I may say, in every example of the quasi dull, but not absolutely dull sound, this short duration character is to be detected, and when it is present on one side important disease may be predicated. The disease will frequently turn out to include tubercular small recent cavities. The comparative duration of the sound on the diseased side is readily established by percussing the healthy side immediately before or after percussing the diseased side. I have frequently found this short duration percussion sound only in the third stage of phthisis. This percussion sound is certainly a form of the dull sound, but as its chief and most sensible characteristic is its shortness of duration, I have preferred to describe it under this title. While shortness of percussion sound is heard at the apex, clear percussion generally holds at the base, but it is by no means rare to find dullish, dull, or even absolutely dull percussion at that part.

The *dull* percussion may be divided into three varieties: 1, the dullish sound; 2, the dull or decidedly dull sound; and 3, the absolutely dull sound.

The dullish sound is a common sign in phthisis in the third stage. It is heard to proceed from over the seat of cavities, and also from over the seat of consolidated lung which presents a cavity at another part. It is with the sound as connected with percussion over a cavity that we have now most to do. In recent examples of cavities, it is more common than in the old standing. But even in old standing examples of phthisis, and even after cavities have been present some years, it is by no means uncommon to find this dullish, or moderately dull sound, only. I have at this time under my care, several examples of pulmonary cavities, in which the dulness is moderate, and differs very little from the percussion sound of the opposite and healthy side of the chest. I observe that these examples occur more particularly in the more easy and comfortable ranks of life, and more among females than males. I presume that the small amount of dulness is due in part to the care that has been taken of the patients, and to the absence of strong inflammatory action calculated to produce consolidation and firmly binding adhesions. Of twenty examples of dulness examined to-day (September 4, 1860), three, or fifteen per cent. are dullish. One is associated with the cracked-pot or the chink sound. Dullishness above is very frequently associated with dullishness at the base; decided dulness is not uncommon; and I have sometimes found absolute dulness at the base, dullishness depending on some tubercle and congestion; dulness under the same conditions aggravated or conjoined with hepatization, and absolute dulness upon the presence of empyema, very complete hepatization or great solidification from congestive inflammatory action, or the condensation that remains after rather long continued empyema.

The dull or decidedly dull sound of the percussion stroke in this stage of phthisis, is the more common form of percussion sound. It is a sound of decided and unequivocal dulness, but yet decidedly less dull than what is usually understood as absolute dulness, or the dulness of empyema. It is short in duration. The parts struck appear to have a range of vibration decidedly greater than holds in cases of absolute dulness, but smaller than in cases of mere dullishness. The sound produced indicates the presence of some air beneath, though greatly less than natural, and of coagulated lymph and generally of adhesions. The rate of the occurrence of decidedly dull percussion is exhibited by the examination made to-day (September 4, 1860), for the purpose. Of twenty examples of dull percussion in decided cavity cases, sixteen belong to the division of decidedly dull percussion, that is eighty per cent. Three of these examples of decidedly dull percussion are associated with the cracked-pot or chink or clink sound. This dull sound has for its pathological conditions much condensed pulmonary structure around the cavity, and invariably, or almost invariably, extensive, and very firm adhesions at the apex of the chest. The dulness usually extends from the supra-clavicular space down to the third rib. Of the sixteen examples just referred to, in fifteen the dulness occupies all this area. In one case the dulness descends only as low as the second rib. This case has been rather rapid, the patient is dying, and for the first time, the cracked-pot sound has been made out to-day. While dulness is present above at the seat of cavities, it will generally be found, except in some very recent cases, that the percussion sound is modified at the base of the chest. It is very often dull: absolute dulness is not uncommon, and tympanitic resonance is occasionally heard; I mean the resonance of pneumothorax.

The absolute dulness of phthisis in the third stage is much the dulness of empyema, or of absolute hepatization of the lung. It is a form of dulness very decidedly greater than the decided dulness above spoken of. It is not a mere useless subdivision. It is rarely met with. The sound is such as indicates the total absence, or nearly the total absence, of air in the pulmonary tissue and bronchial tubes beneath. It resembles the sound made by percussing the finger held in the ear.

Of the twenty examples of dulness examined for the purposes of this description, only one was of the absolute dulness description. This is at the rate of only five per cent. The example of absolute dulness referred to is perhaps scarcely so dull as the dulness of empyema, but is materially duller than the decided dulness above described. It occurs in a female, about sixteen years of age, and is associated with very marked cracked-pot sound, or clink sound. The cavity is large, of some months' standing at least. The patient had been much exposed to cold and rain, in going to her employment as a dressmaker, in the morning, and returning home at night. Since the above was written, I have met with two or three cases of absolute dulness at the apex in cavity cases. There is now (Jan. 23, 1861) under my care in the Paget Ward, a man named M'Henry, who has a cavity on the left side. The percussion note is that of the finger struck in the air. Cracked-pot sound, as in the above-described case, is well elicited on percussing the chest of this patient. In treating of the absolute dulness which we note in the third stage of phthisis, it is right to mention that this sign is found in those examples of disease in which the liver becomes degenerated, greatly enlarged, and, encroaching upon the right side of the chest, pushes the lung upwards.

The cracked-pot sound, or, as it is denominated by the French, *bruit de pot fêlé*, is a remarkable sound, and is always associated with shortness of duration of the percussion sound, or one or other variety of the dull sound, most frequently with decidedly dull percussion. This form of percussion does not take the place of dulness; it is superadded to dulness. Frequently a case of phthisis in the third stage will exhibit, or be marked with, simply dull percussion, for weeks or months, and all at once the stroke of the fingers will elicit a new, short, money chink or clink sound in addition, which shall almost startle the bystanders. This sound, though it may be absent or not producible for many hours, or days, or weeks, may be said to remain in general to mark the case to the very end. The essential element in the sound under consideration is a loud, metallic, cavernous, abrupt sound, of short duration, suddenly arrested, and proceeding from hard, rather bound, materials, as walls of a cavity containing air, and in violent vibrations. These vibrations are greatly confined, i.e. are not propagated to a distance amongst the solids. The vibrations proper to the sound are nearly confined to the area of the cavity walls.

The cavity walls which emit the sound are hard, capable of arresting or resisting the undulations of the contained air, and fitted to give out an almost metallic, glass, or earthenware sound. Were the walls porous, soft, and yielding, no such sound would be produced. In the production of this jarring clink cavity sound, violent agitation of contained air is necessary. We know this from the fact, that air in a cavity is essential, and that a strong or violent blow is necessary for the production of the sound. The production of violent agitation of the air in a cavity is greatly promoted if part of it escape pretty freely during the blow. If air be completely confined so that it cannot suddenly escape in part, the agitation of the air is impeded, and, under such circumstances, the *bruit de pot fêlé* sound is not obtained. The escape takes place by one or more bronchial tubes. When an india-rubber bag, filled with air but completely closed, is percussed, however abruptly, violently, and quoad this cracked sound, happily, no such sound will be produced; but if an opening communicate freely with a tube connected with it, the sound produced is of the character under notice. We see, therefore, that some degree of freedom of the contained air is necessary. The confined air in the closed bag or cavity, struck and driven in, simply becomes compressed, and it presses so firmly upon the walls of the cavity as to forbid them full vibration. When the air escapes in part, the remainder in the cavity, as well as the part escaping, freely vibrates. The state of the cavity air most favourable to the production of cracked-pot sound, and indeed essential to it, is a certain amount of freedom. It will therefore appear that a tense state of air is unfavourable to this sound; and yet it is curious that Dr. Bennett, of Edinburgh, should say that tense air is essential. This is clearly opposed to my *experience*, unless Dr. Bennett attaches a meaning to the expression "tense air" different from what is usually done. It is true a certain amount of confinement is necessary. Were the cavity very open, the blow struck over it would be immediately diffused, and that amount of agitation of the air would not be secured that is necessary to produce the sharp jarring chink or clink of the hardened walls. A momentary compression of the air doubtless takes place, but this is immediately relieved by the escape of air through the bronchial mouth or mouths, and this escape seems essential to the rapid, jarring, short-lived vibrations of the walls—one of the causes of the sound.

The seat of the true chink or clink sound in phthisis is invariably the upper front of the thorax. The most common part for the production of this sound is the first interspace and the second rib. The second interspace sometimes is the only part which emits it. I have occasionally found all these parts, in the same patient, emit this remarkable sound. In a very few examples I have found this sign producible on both sides of the chest; but it is usually confined to one, even when cavities exist on both sides; and we find a reason for this in the fact, that though both sides present cavities, only one may have that character of cavity which is capable of those movements essential to the production of this clinking sound. I have found more examples of this sign on the left than on the right side of the chest. I only once obtained this peculiar kind of sound from the supra-clavicular region. This was when percussing the dead body. A cavity existed underneath the part, the percussion of which *caused* the clink.

The circumstances of age and general condition of health under which this jarring, clinking sound is produced, is pretty well exhibited by the following table of nine instances of this sign found in the wards of the Hospital for Consumption. It would have been easy to have multiplied the examples. The cases having been taken from the female wards accounts for the absence of males:—

Age.	Sex.	Seat of Sound.	Seat of Disease, &c.	General State.	Duration of Disease.
14	F.	Left apex.	Left. Cavity.	Fair.	1 year.
30	F.	Left apex.	Left. Cavity.	Very weak.	Years.
19	F	Left apex.	Left. Cavity.	Weak.	6 months.
43	F.	Left apex.	Left. Cavity.	Very weak.	10 months.
17	F.	Left apex.	Left. Cavity.	Very weak.	4 months.
16	F.	Left apex.	Left. Cavity.	Weak: feverish.	Many months.
20	F.	Left apex.	Left. Cavity.	Fair.	9 months.
23	F.	Left apex.	Left. Cavity.	Good.	1 year.
40	F.	Right apex.	Right. Cavity.	Exhausted.	1 year.

In my experience the true clinking cracked sound is found in cavity cases only. The cavity is large, and generally of some considerable age. The patient is usually exhausted, but I have not found it to be precisely what Dr. Cotton describes it,—the death-knell of the patient. If a death-knell, it is one which is occasionally, in my experience, *tolled for many months.* I have a young patient, now under my care, in whom this "knell" will likely continue for a year, judging from her general fair state of health, and the absence of active vascular action in the lungs. It is, however, doubtless, on the whole, a sign of the very gravest significance. Speaking of the alleged cracked-pot sound of the healthy chests of children, Skoda (Markham's edition) says, "I have never observed it there myself."

It is sometimes only at the very latest period of the disease that the cracked, clinking sound is producible. On percussing a young man lately in the hospital, who had frequently been percussed before, this sign was only now produced. This was only a day or two before his death.

The sound reaches the ear of the physician direct through the air, from the thorax, and also through the mouth and nares. That the sound is partly communicated by the mouth and nares is proved by placing the ear near these parts. The sound is always heard most strongly when the patient's face, with the mouth open, is turned to the listener.

The sound, both as it proceeds direct from the chest and from the mouth of the patient, is always strongest when the mouth is well opened. The open mouth seems to be very favourable to the movements of the cavity upon which the sound depends. In some examples a clinking sound, audible when the mouth is open, is no longer so when it is shut. We find an explanation of the importance of an open mouth in this, that it favours the free escape of air from the cavity.

When percussing the chest, it is, therefore, proper to cause the mouth of the patient to be kept open, if we desire to afford every chance for the production of this characteristic sound. The physician who observes this rule will certainly meet with many more examples of this sound than he who neglects it; and it may be here observed, that this and other such differences in the method of investigation, are at the bottom of the very different results in respect of the frequency of this sound that have been attained by different observers.

The most successful mode of percussion in respect of the production of this sound is this: — The forefinger of the left hand, used as a pleximeter, is laid along an intercostal space, and this is struck with an abrupt, strong blow, delivered by the fore and middle fingers of the right hand. A good aim should be taken so as to drive the finger pleximeter well in, in the direction of the cavity. A feeble blow, or a blow delivered on the side of the finger, will not only generally fail, but it will cause, for the most part, all other blows which may be delivered at this trial to prove useless. This depends upon a fact soon to be noticed. Some physicians employ pleximeters of ivory, others employ a pleximeter and a hammer. But, in my experience, I have found the mode of percussion above described not only highly simple, but as certain and as successful as any other, in respect of the production of this sound. In examining a patient lately, I found an exception to the rule that a violent blow is necessary. I produced the sound fully with a gentle tap, the patient being too ill to be roughly handled. In percussing, I generally employ the fingers only. The finger fits less happily on the right than on the left side.

A full condition of the cavity in respect of air is necessary for the eliciting of this sign. If emptied of air by frequent percussion, the cavity will obstinately remain dumb, quoad this sound. When the sound can no longer be produced, a full inspiration will sometimes suffice to restore it.

The sound under description is so peculiar that it invariably attracts the attention of bystanders and attendants. I have seen them startled by it. I lately inquired of a young woman from whose chest I had obtained the short clinking sound, what sort of sound it was? She replied that it was a "cracked sound." Another young woman, an attendant, said, on a late occasion, that it was a "chink"—meaning a clinking or chinking money-sound.

The rate of frequency of clinking or cracked-pot sound varies greatly with the class of cases under examination, and according as these classes come under observation, the rate, of course, will vary. Some physicians find this sound very frequently in their practice, while others hear it rarely. Physicians who see cases of phthisis in its first two stages, or an early part of the third or cavity stage only, or more particularly, seldom hear it, and with a somewhat pardonable laxity of logic, conclude it to be generally a very rare sign; while others, who see phthisis only or chiefly in the third stage, or just before its fatal termination, discover this remarkable sign very frequently; and again, on their part, with a similar looseness of reasoning, conclude that it is generally a frequent sign. The first class of observers are disposed to regard the latter class as imaginative, and the latter are not indisposed to ascribe the negative results of the first observers to want of skill in the small art of percussion.

In hospitals and dispensaries dedicated to the treatment of consumption, and in the practice of physicians specially devoted to the treatment of chest diseases, the cracked-pot sound is heard in a rather large proportion of cases, while in general practice, or in the practice of those who see diseases chiefly in an early stage, it is of comparatively uncommon occurrence.

The rate of frequency even in the same hospitals, and in the practice of the same physicians, is apt to vary. I lately examined forty hospital patients suffering from chest disease with a special regard to this sound, and I found that two only presented it, being at the rate of five per cent.; while a few days back I examined forty patients under the same general conditions, and of these five presented this sign, being at the rate of 12·5 per cent. These patients were all inmates of the Hospital for Consumption, and suffering from phthisis in different stages, or from other chest maladies. Of the latter batch of cases twenty-one had cavities, so that the cracked-pot sound, in respect of them, was heard at the rate of 23·8 per cent. The rate of 23·8 per cent. in cavity cases is much above the usual hospital rate. It may be supposed that, writing upon this subject, I have been making extraordinary efforts to obtain it, or that I have been imaginative. This is simply not the case. The result has come uninvited. Were proof of this required, I might mention the convincing fact, that having, with my returns in my hand, casually mentioned to the house-surgeon, Mr. Edwards, that I had been taking the statistics of the cracked-pot sound, he replied that it was a curious fact, that there were more examples of the cracked-pot sound now in the house than had been observed for a long period.

The cracked-pot sound, it has been already remarked, is very liable to temporary absence. This is usually due either to the cavity having been more or less deprived of its air, or to the bronchial mouths being occluded by mucus, or by other causes.

The cracked-pot sound disappears occasionally altogether when the bronchial mouths are permanently occluded, as by the pressure of enlarged bronchial glands, or by the contraction of the cavity walls. Perforation of a cavity giving rise to pneumothorax, it is reasonable to believe, would prevent the further production of this sound. I have not actually met with a case of perforation, to my certain knowledge, putting a stop to this sign; but it is evident that the pressure upon the exterior of the walls of the cavity would so compress and empty it as to render the production of the cracked-pot sound all but impossible, if not completely so. It appears also that this sign may now and then be destroyed by a cavity becoming filled with blood, in cases of hæmorrhage, or by the presence of much secretion; but I may mention that I have not actually met with instances of the loss of the cracked-pot sound under the circumstances referred to.

The cracked-pot sound has been procured by me from the dead body, by percussing the lower costal cartilages where they overlie the liver, when the abdomen having been opened, air has been present between the costal cartilages and the liver. The rattle and clink, loud and discordant, have been very marked at the moment that the air has been discharged from between the two surfaces. The experiment may be readily repeated by others. The mechanism of this sound is much the same as of that which proceeds from the thorax in phthisis. The mechanical conditions are much the same in both cases. There is a blow, there is air between two resisting surfaces, and there is an escape of the confined air, though not a very free one. The production of the cracked-pot sound over the liver throws some light upon the mechanism of the sound obtained in phthisis.

When examining the body of a patient (Farrell), a few days back, who died of perforation of the lung, &c., I percussed over the liver, the abdomen being open. To the surprise of those around, the cracked-pot sound was elicited.

A variety of percussion sound, which may be named the dull hollow sound, occurs occasionally in the third stage of phthisis. This title seems a contradiction in terms, but a sound is occasionally heard to which it is really applicable. Perhaps it would be less objectionable to call it a hollow sound, of short duration, and of limited local area. It has been described by other writers. Skoda speaks of such a sound under the title of an empty sound, and it has been likened to the sound obtained by gently striking the distended cheek. It is a sound of a part containing air, the enclosing solid parts taking on very little vibration, and being either in their nature or in their adhesions incapable of emitting a prolonged sound, such as we have in the percussion of healthy parts of the chest. Skoda, I believe, would designate this variety of sound as an empty clear one.

This sound may be obtained in the case of some large, old, dry cavities filled with air, and approaching near to the surface of the chest. It is usually obtained over only a small space, and is bounded by parts which give out usually one or other of the varieties of dull percussion. A gentle blow with the finger, I have found most successful in eliciting it. An increase of resonance is occasionally obtained in the cavity stage of phthisis under the clavicles, when liquid to a considerable extent fills the chest, compresses the base and middle of the lung, and causes it to rise and fall back in the direction of the vertebral column. It is not precisely a tympanitic sound, but in loudness and fulness it approaches it. It has been taken notice of by Skoda and by Dr. Williams. This sound is louder than percussion elicits on the healthy side. It comes with the advent of effusion, and goes with it also. I have heard several examples of this sound, but they have all been associated with great effusion, and the cavernous sounds somewhat reduced, it is true, have left no doubt whatever of the nature of the case. It appears to me that the presence of effusion and the compressed state of the lung beneath, so confine the sonorous vibrations produced by percussion, that increased resonance is obtained. The sonorous undulations are not permitted to decay by diffusion through the tubes and the vesicular structure of the lung. This increase of resonance is to be distinguished from the tympanitic sound of perforation. The first is limited to a small area under the clavicles: it is the successor of simple dull percussion, and beneath the percussion is absolutely dull. The percussion all beneath the clavicles is thoroughly tympanitic in cases of perforation until effusion takes place.

A very moderate increase of resonance is now and then found over a considerable portion of the middle or lower part of the lung in the third stage of phthisis, when this is associated with considerable emphysema. Though not great, this increase of resonance is readily appreciated. It is recognised by very protracted and loud wheezing expiration, and it is known not to appertain to perforation by the absence of that very full and drum-like resonance which marks perforation, and of amphoric blowing and amphoric voice. It is well to know that in the third stage of phthisis emphysema may give rise to this form of increased resonance, but it is of rare occurrence. I have seen, I think, only two or three patients in whom these conditions were distinctly recognised.

The tympanitic sound is not unfrequently heard towards the close of the third or cavity stage. When fully developed, it is invariably due to perforation, and the escape of air into the cavity of the pleura. It is recognised not unfrequently by physicians who examine their dying patients, and there is reason to believe it would be much more frequently found if it were more frequently sought. The desire to avoid causing pain and distress to the patient when exploration can prove of little service to him, is doubtless the creditable cause of the unfrequent discovery of this sign. Of this form of percussion I shall speak when I come to treat of the fourth or perforation stage of phthisis, the natural and the not infrequent termination of the third stage.

I would here remark that I have never found a true tympanitic sound proceed from a mere cavity, however large. Auscultators speak of amphoric percussion sounds proceeding from cavities: if they mean true tympanitic sounds, I have never heard them, and I believe the signs are due, when heard, to other conditions, viz., those of perforation. It may seem curious and difficult of explanation, that when a large accumulation of air is contained in a pulmonary cavity, percussion should not give out a drum-like sound. This difficulty, however, is solved when we reflect that the solid parts, unlike the solid parts of a drum or the pneumothorax side, are not free to vibrate, but are bound and tied down by stiff and resisting adhesions and tightly cementing materials. If tensely air-filled small bladder sounds may be called tympanitic, I have heard them proceed from cavities.

CHAP. XXXIII.

THIRD STAGE — *continued.*

Position of the Chest.—Changes of Form.

Position of the chest in the third stage of phthisis.—It has been already observed, when I was treating of the earlier stages of this disease, that the position of the thorax, in respect of other parts of the body, is frequently morbidly altered. In the third stage, the alterations of position are more frequent than at either of the two preceding stages, and they are also much more developed. They present themselves in a very marked manner in a large proportion of cases which attain to the cavity period. These deviations keep pace with the progress of this stage. As the patient becomes worse the changes are rendered more conspicuous, and even if he improves when his cavity is becoming quiet and silent, and is contracting; still the changes progress. It is true that the extreme elevation of the chest and shoulders incident to severe dyspnœa, dependent upon temporary bronchitis, mixed with asthma, or upon effusion in the vesicular tissue, or into the pleura, partially subside as these conditions are removed. The elevated shoulders, and the projection forward of the trunk from the loins, tend to increase in the third stage of phthisis.

Instead of the transverse plane of the chest occupying the transverse plane of the body, it occasionally happens that it is placed obliquely. One shoulder, generally that of the healthy side, is more advanced in front than the other. This arises from a certain twist in the spine that the contraction of the unhealthy side of the chest has given rise to.

One shoulder is occasionally seen to be very much more elevated than the other. This is due, as we shall presently see, to contraction of the side and depression of the ribs of the opposite side, and in some cases, in part, to lateral curvature of the spine consequent upon the pulmonary disease.

The changes in the shape of the chest, in the third stage of phthisis, are amongst the most striking and reliable signs appertaining to this period. It is in a very small proportion of cases of phthisis in the third stage of any standing that we cannot at once detect a very material deviation from the natural configuration of the chest. Of one hundred out-patients who came under my care, when assistant-physician to the Hospital for Consumption, only one in the third stage of phthisis presented his thorax altogether free from acquired mal-configuration.

I regard the deviations from the normal shape of the thorax in the third stage of phthisis with great interest, and I presume not unreasonably. They serve to indicate the extraordinary influence of the disease of soft parts upon the solid framework of the body; they at once meet the curative or remedial requirements of urgent and dangerous morbid conditions, and afford to the mind ocular and striking evidence thereof. Besides this, these deviations often aid the most skilful physician, the most able auscultator, with evidence which gives a certainty to his otherwise hesitating opinion. With a perhaps excusable pride and a pardonable confidence, how often have I been enabled, with perfect accuracy, to diagnosticate a tubercular cavity in my wards in the Hospital for Consumption the moment the fresh-arrived patient has stripped off his shirt! The few words relative to his history uttered during the act of undressing, and the momentary observation of the shape of his chest, have suggested the probable nature of his malady and its stage, to be rendered absolutely certain a moment after by the discovery of cavernous respiration and cavernous voice.

The alterations of shape of the thorax in the third stage of phthisis are greatly more frequent than in the two preceding stages. That is to say, the ratio of examples of departure from the natural configuration to the total of cases in the respective stages is greater in the third than in the other stages. Comparatively few examples of cavity phthisis of greater than very recent date are free from some degree of acquired mal-configuration of one or other variety. Of some twenty well-marked and undoubted cavity cases, at present in the hospital subjected to examination for this injury, all present mal-configuration of the thorax, more or less marked, obviously the result of pulmonary disease. In my paper, published in the "Archives of Medicine," on the change of form in the chest, it appears that of thirty-nine cavity patients, only one presented a fully healthily formed thorax.

The varieties of mal-configuration observed at this period of pulmonary consumption are more numerous than in the two preceding stages. They are: 1, double flattening; 2, single flattening; 3, depression; 4, depression of summit of chest, with descent of clavicle and scapula; 5, retraction of intercostal spaces; 6, intra-lapsus of upper part of sternum; 7, lateral deflection of sternum; 8, longitudinal obliquity of sternum; 9, undue angularity of the articulations of the sternum and the costal cartilages; 10, undue angularity of the articulations of the costal cartilages and the ribs.

The following table exhibits the varieties of the change of form observed in thirty-eight examples of mal-configuration observed in cavity patients referred to in my paper on the change of form of the chest contained in the "Archives of Medicine."

Flattening on one side.	Flattening on both sides.	Angularity of one side.	Angularity of both sides.
20	5	11	2

I have already written so much on the changes of the thoracic form, that I deem it inexpedient to prolong the discussion of the subject in this place to a great extent. But I believe that information of some interest is contained in the paper to which I have been referring, and I therefore insert it at the conclusion of this work.

The cases of cavity in which no marked mal-configuration of the chest is observed, are for the most part those in which the lung structure has rapidly broken down, in which the early and much-developed hectic fever soon brings the patient to the mortal termination of his disease. In such cases there is little time, and, for the most part, little power to produce those plastic exudations and adhesions which play such an important part in the mal-configurations of the thorax. Without pretending in this instance to great accuracy, derived from extended statistical data, I may express my opinion that the examples of non-alteration are most frequently found in the young and irritable, particularly of the female sex.

Before concluding, I would desire to say that too implicit trust must not be placed upon the presence of single depression or flattening, as evidences of cavity. I have, since I wrote my paper, seen three cases of cancer of the root of one lung, which was attended with marked depression on the unhealthy side, and with very dull percussion. The tumour in these cases sufficed to press upon the bronchial tubes and prevent inflation of the lung, but had not attained to that size to compensate for the loss of volume of the lung, or, as it often does when of long standing, to exceed it. Signs of pressure upon the bronchi and œsophagus, and of the great arteries and veins, are generally present in cancer, and serve to direct the diagnosis. In cancer the respiration is generally either absent, or of loud blowing tubular constrictive character, and the voice is weak and difficult. Cancer, by no means an unfrequent disease of the root of the lung, particularly on the right side, occurs seldom under forty years of age.

The extent to which the different varieties of mal-configuration of the chest proceed in the third or cavity stage of phthisis, is much greater than in the two preceding stages. Yet it is to be borne in mind that this is only a general rule, and that we occasionally find mal-configuration in a case of phthisis in the second, and even in the first stage, to exceed the amount of deviation seen in another case of phthisis in the third or cavity stage of the disease. As a general rule, the mal-configuration of the third stage is very striking, and with a physician, or even a non-professional looker-on, accustomed to use his eyes scrutinizingly, the departure from the healthy form of the chest, in most instances of phthisis at this period, is sure to attract notice. The mal-configuration is so very great in many instances, and gives rise to so much abnormal lateral curvature, antero-posterior curvature, or even partial twisting of the vertebral column, as to lead the observer to the conclusion that the chest's form is not dependent upon the pulmonary disease, but is of anterior date, and possibly, instead of being the *result* of pulmonary disease is really the *cause* in some measure of it. In such cases the patient will generally say that he was not aware till the moment of inspection that his chest was not of healthy form, and that he never had the reputation of having one shoulder lower than the other. This is not the case in congenital malformation, or in malconfiguration due to simple curvature of the spine, or to long-continued unnatural position, as in trade; the patient usually knowing that this peculiarity was antecedent to his pulmonary disease.

The alterations in the shape of the chest, in the cavity stage of phthisis, due to the occurrence of empyema, are rather more frequently seen than in either of the preceding stages. These alterations have been already described, and it is therefore unnecessary to reproduce them. The same may be said of the modifications of the form of the chest due to hepatization.

The changes of form in the chest which are observed to occur on the perforation of the lung, and on the consequent presence of air in the pleura, fall to be described in the fourth or perforation stage of the disease. It has hitherto been described by writers in the third stage, when described at all; but for reasons that have been already stated, and others which I intend to detail at a later period, I have decided to constitute the perforation period as a separate and new stage of phthisis. Under this head I shall treat of the changes of shape and of other physical signs occurring under this accident or event.

CHAP. XXXIV.

THIRD STAGE — *continued.*

Movements of the Chest.—Rapidity.—Local Deficiency.—Upper Front.—Lateral Regions.—Base.—Entire local Loss of Motion.—Excess.—Movements of Larynx.—Vocal Fremitus.—Increase.—Diminution.—Cardiac Impulse at Interspaces.—Diagnosis.—Mechanism.

The movements of the chest in the third stage of phthisis, on the whole, are very much affected. In this stage the movements taken together may be said to be increased; but the distribution of the motion is very different from what we find in health. The frequency of the elevation of the ribs in the inspiratory effort is usually very much greater than in health. The frequency varies, however, very considerably with the period of the stage, with the size of the cavity, the amount of non-respiring lung, and with the active or non-active condition of the local disease and the presence of hectic fever. When the cavity is small, has been recently formed, and is unaccompanied with excited vascular action, the rate of the respiratory movements may little exceed that of health. When a cavity of some months', or even years' standing, becomes silent and inactive, and is unassociated with pressing conditions, such as extensive tubercular infiltration, or pneumonic affections, the respiratory movements, which had formerly been very rapid, may come down to a point not much raised above the natural standard. In acute attacks of pneumonia, or during the rapid deposition of fresh tubercle, during pleuritic attacks, the respiratory movements may rise to a very exalted rate. The frequency may reach to one hundred in the minute. As the disease approaches its mortal termination, the respiration movements usually become accelerated and laboured; the debility, the weakness of the heart, and the presence of mucus and serous fluid in the lungs and bronchi, dependent upon faltering powers, all contributing to this result. In some patients, however, the frequency of respiration is not materially increased, even up to a short period of death. When death approaches through exhaustion, rather than by asphyxia, this is most observed. The sudden death by hæmoptysis is not uncommonly the fate of those whose respiration movements had been comparatively tranquil. It is in cases of phthisis reaching to the perforation period that the respiratory movements are most signally accelerated. The respiratory distress in these cases is almost always extreme; but this falls to be described under the new or perforation stage of the disease.

The condition in the respiratory movements most characteristic of the cavity stage of phthisis is local deficiency. While the general movements are not only accelerated, but increased in extent and in obvious effort, a deficiency, often very remarkable and striking, is observed. Deficiency is observed under several conditions, but the deficiency which we note in connection and in immediate dependence upon the presence of a cavity, is that under one or both clavicles, which has long been regarded as peculiarly the characteristic deficiency of this stage of phthisis. The first, second, and third ribs, with their interspaces, are little raised in inspiration.

The characteristic deficiency of motion in the third or cavity stage of phthisis, is always or nearly always associated with loss of the natural prominence of the upper front of the chest, or in other words, with the flattening and depression which have been described when I treated of the changes in the form of the thorax occurring at this period of the disease. The extent to which the deficiency extends varies much. In recent cases it may be very slight and not perceptible, excepting under the test of a forced inspiration, when the healthy side will be found to exceed the unhealthy side in elevation. Again, it may be very great and force its presence at once, so to speak, upon the mind of the observer. The loss of motion is not unfrequently complete, and the first, second, and third ribs, with their intervening soft parts, remain perfectly motionless under the respiratory efforts, either natural or forced. If in these last cases any movement is seen, it is independent of respiration, is confined to the soft parts between the ribs, and more frequently on the left side than on the right, and is due to the movements of the base of the heart and the great arteries, to be presently noticed. Dr. Sibson's stethometer applied to the upper front of the chest exhibits well the loss of elevation. Dr. Quain's stethometer does the same thing for the loss of expansion. The loss of motion is almost always associated in phthisis with dull percussion. The dulness and the loss of motion usually proceed pari passu. In a few instances the loss of motion is accompanied with a loud percussion sound, due to the presence of liquid compressing the body of the lung, sometimes with tympanitic percussion, when perforation has taken place. A small bag percussion sound of short duration is sometimes obtained.

The loss of motion at the upper part due to a cavity is usually attended with some considerable amount of motion at the base, but sometimes with great reduction there, in consequence of the presence of consolidation. The motion at the base is nil, when, in addition to a cavity above, we have empyema below, or air, the result of perforation, or of the putrefaction of effused liquid. Loss of motion at the upper front, it is to be borne in mind, is occasionally due to other conditions besides cavities. It is met with, though rarely, in cancer of the root of the lung. Aneurism of the aorta gives rise to it occasionally, when it presses for a considerable period on a bronchus. Tumours of the mediastinum do the same. Signs of pressure and pulsation and prominence are generally present in these latter diseases. Cancer is sometimes attended with flattening. The proximity of the heart to the thoracic walls, evinced by a visible and a palpable impulse, especially when the cavity is situated on the left side, help in the diagnosis.

A form of deficiency of motion in the third stage, is one of expansion of the ribs at the lower lateral regions. The ribs are more than usually moved upon the vertebræ, and the upward motion of the lateral or external part is consequently increased. But the expansion or outward movement of the outer part of the ribs is reduced. Great deficiency of motion laterally takes place, even when an increase of upward movement is obvious. That such deficiency of motion really takes place seems to be contradicted in many cases by the very obvious fact that the ribs are in more than usual motion from the strong respiratory efforts which the patients make. But it will be found on further examination that this motion is different from that which takes place during healthy breathing, and still more during forced respiration. In this case of deficiency, the motion that is defective is that of the rib, not upwards but laterally or externally. In the case of increased movement, the motion is of the thorax upwards, as a whole. In this latter case the ribs do not separate normally from each other, and by outward movement, at the parts distant from the spine, increase the distance between them, and thereby fail to increase the cavity of the chest; they are simply lifted, without performing fully that expansive movement which is necessary for the augmentation of the cavity and for the full inflation of the lungs. However, the non-expansion is an effect and not the cause of the non-expansibility of the now undilatable lung.

This deficient form of movement is readily detected by the eye, and may be well recognised by placing the palm of the hand upon the side. If the deficiency holds, as is generally the case, on one side only, then by placing the two hands respectively on the healthy and the unhealthy side, we become very sensible of the loss of motion. The stethometers exhibit the loss very well. This deficiency, too, may be detected very accurately by applying the tape measure. Inspiration, on the diseased side, will drag the sternal end of the measure perhaps only half an inch, while the same act will drag it on the healthy side one or one and a half inches. The tape, of course, is kept fixed at the spine, and held loose at the sternum.

Deficiency of motion at the base of the chest is found to some extent in nearly all examples of cavity phthisis, and is due for the most part to tubercular or pneumonic condensation, almost universal in old standing cases.

Total loss of motion is seldom found at the base from hepatization, or tubercular consolidation, or serous infiltration. But it is found in cases of empyema of some extent. It is also found in cases of perforation, in which a large quantity of air fills the pleura, and cannot be evacuated in consequence of the mechanism of the aperture being such that admits air only into the pleura, and not out of it. But this falls properly to be more detailed in the perforation—or fourth stage of the disease.

An excess of motion of the chest, or rather of the shoulders, is a frequent accompaniment of the third stage, more so than in the two preceding stages. Such is the little accommodation for air in the lungs, and such the urgent requirement for the aeration of the blood-loaded lung, that every help is eagerly sought by the patient; and as some little aid is obtained by the vigorous use of the muscles of the neck, which are attached to the scapula and clavicle, these are kept in active employment with the result of raising the shoulders. The lifting of the chest in mass is mainly effected by the extraordinary employment of the pectoral muscles, of the serratus magnus, and the sub-clavius.

To the extraordinary movements of the chest in the third stage of phthisis may be added the great movement of the larynx which we not unfrequently observe. The larynx is alternately depressed and raised, often to a very abnormal extent. This occurs when the dyspnœa is very great, whether this depends upon the thoracic disease only, or conjointly upon that and ulceration and obstructive disease of the larynx and glottis. Under these latter circumstances, it is not unusual to observe the head of the patient thrown back, and the lower jaw strikingly depressed at every inspiration. The nares, too, are often seen to be dilated at inspiration ; the alæ nasi to be freely moved or flapped outward at every inspiration.

The thoracic vocal fremitus it may be permitted to describe under the movements of the chest. This motion or vibration of the thorax in the third or cavity stage of phthisis is usually altered, as is the case in the two preceding stages. The fremitus is not constantly increased. In many examples it is decidedly diminished. In the majority of examples of phthisis, it may be said that the vocal fremitus is increased; and in a large proportion of cases of increase, the augmentation is very decided. The hand placed upon the chest is more shaken than usual, and the stethoscope may be felt almost to tremble with the strength of the thoracic vibrations. The excess of vibration is chiefly experienced above the mamma. It is seldom found under the angle of the scapula, unless a cavity exists close at hand. I have found the increase of vocal fremitus greatest in the case of moderately-sized cavities, with condensed pulmonary structure around, and with some considerable thickness of wall in front. The right side of the chest has, I believe, presented the most marked instances of this increase. Males have been more frequently than females the subjects of great augmentation of vocal fremitus. The large larynx in a state of health, and the sonorous grave voice, are the common associates of increased fremitus and contribute to its development. Increased vocal fremitus is usually associated with strong vibrating pectoriloquy and cavernous not amphoric respiration.

The diminution of vocal fremitus is not unfrequently an attendant upon cavity in the third stage of phthisis. This has not usually been acknowledged. In a moderate minority of cases of cavity it is observed. If the respiration on the opposite side of the chest be full and healthy or puerile, the diminution of thoracic vibration on the diseased side is made more manifest by the full vibration which now attends the respiration of the sound side. I have found the reduced fremitus to attend two kinds of cavities. The first is the cavity which is greatly contracted, and the inflation of which is prevented by depression of the thoracic walls, by the shortening of thick adhesions and by plastic materials. The second is the very large cavity, with thin walls, in which are produced extensive area or diffused amphoric sounds, and having only imperfect bronchial air communication.

In the first case, the bronchial openings, it is to be supposed, are pressed upon and invaded; and this by reducing the extent of the column of air in vibration, interferes with thoracic fremitus. In the latter case, the vibrations of the air are too much diffused in the large chamber, and the walls of the cavity are too thin and have too little momentum to produce strong vibrations of the thoracic walls. The whispering or suppressed voice of laryngeal ulceration, &c., the weak female voice, and the low tone and bronchial obstructions are favourable to the loss of thoracic vibration or fremitus. I have found the reduced thoracic vibration of the voice in many examples of phthisis, in the third stage, over the seat of cavities. I have almost always in the hospital, out of some twenty cases of cavity, one or two specimens of this negative sign. The presence of reduced vocal fremitus at the base of the thorax, and over condensed non-cavity lung, but beneath a cavity contained in the apex, is very common. While increase of vocal fremitus is the rule at the apex, the diminution of it is the rule at the base. The reason of this seems to be sufficiently obvious. The amount of consolidation at the base is sufficient to prevent that amount of air communication necessary to effect full vibration. With reduced vocal fremitus at the base, there are usually associated defective respiration, often mixed with crepitation and rhonchus and defective voice, both well made known to the mind by the employment of the differential stethoscope. It is almost needless to observe, that the presence of liquid in the pleura is productive of reduced fremitus at the base of the chest.

CARDIAC IMPULSE AT THE TWO UPPER INTERCOSTAL SPACES. — The first and second intercostal spaces, in a very considerable proportion of examples of phthisis in the third stage, are the seat of a very obvious and remarkable sign which is very rarely or never observed in other morbid conditions. The movements indeed, with their characteristic features, recognisable in general without trouble, may be said to be peculiar to the cavity stage of phthisis. At all events, I have seen no instance of the precise movements under consideration in any other morbid state. The movements in question proceed from the motion of the base of the heart and two great arteries. The motion generally includes a character of impulsion, the same as appertains to the impulse felt over the apex of the heart. It very often however happens that the motion partakes less of the character of distinct and successive pulsations; and judged of by the impression conveyed through the hand, consists more of almost continuous moving forwards and backwards. The words fluctuation and undulation, perhaps, convey well the character of the motion. The fluctuation is continuous and gentle. When the movement is slight, it is best recognised by the touch, less readily by the eye. The extent of the rise and fall varies considerably in different cases. The intercostal space may be distinctly seen to be lifted and to fall back. On the other hand, the movement is so slight as to be not improperly described as a gentle trembling.

The superficial extent of this abnormal movement varies in different cases. In many the motion is seen and felt to occur in two intercostal spaces, and to extend from the sternum an inch or one and a half inch externally. In other examples, the motion is limited to one intercostal space, the first or the second, and to be confined in a lateral direction to a space of not more than one inch.

This movement is seen on both sides of the chest, but only on one side in the same case. It is more frequently seen on the left than on the right side.

The movements at the second and first interspaces are nearly synchronous with the impulse of the heart at the apex. They continue with the impulse in the usual part, and they cease with it for a moment, when the natural impulse is retarded. When the apex beats fast, the motions above are likewise fast, and when slow, the intercostal movements are slow also.

In many examples of this undue localization of the heart's impulse, for such it is, I have found the impulse of the apex weaker than natural. I have also found the seat of the natural apex impulse to be higher than natural by one interspace. In cases of the movement, on the right side of the chest, extending as high as the first interspace, and reaching, as I have seen it, to near the clavicle, I have found the apex impulse at the middle of the sternum.

The relation in respect of time between the impulse of the apex of the heart and the movement or impulse at the superior interspaces, is well exhibited by the employment of the sphygmoscope. It is exceedingly interesting to watch the movements of the sphygmoscope applied respectively on the two seats of impulse. As a knowledge of this instrument may be valuable, I venture to place at the conclusion of this work my paper upon it published by the Royal Society.

The movements under consideration are due to the movements of the base of the heart. This is proved by the several facts stated in respect of the synchronosity, &c., of the abnormal movements, and of the natural impulse of the heart, and of the revelations made by the scalpel. Post-mortem examinations prove invariably that the heart has been brought into undue contiguity with the interspaces and adjoining parts, by the destruction by excavation of the naturally superincumbent lung. In these cases the heart's base and the great vessels are separated from the anterior wall of the thorax by a thin cavity wall, instead of, as in health, by a mass of spongy lung inflated with air. In addition to the undue contiguity mentioned, there often exists a degree of upward and lateral displacement due to the operation of contracting fibrinous exudations.

A young man named Beaston, an hospital patient, presented cardiac impulse at the second and third right interspaces in a very marked manner. I watched this man after he left the hospital till he died. I had then the satisfaction of examining the chest, and I found a cavity about the size of a walnut at the upper part of the right lung, surrounded by hard, condensed, pulmonary tissue and fibrinous exudation. A large cavity had existed previously: this had been reduced by the contracting fibrin, and the heart, in common with other movable parts, had been drawn to the seat of disease. The heart's base was found on the right side of the sternum.

The sounds of the heart are usually extremely loud at the seat of the abnormal movements. When this abnormal motion holds on the left side I constantly find the sounds above much louder than the sounds at the fifth interspace, the seat of normal apicial impulse and of greatest intensity of sound. I have occasionally found the sounds louder even at the second right interspace than at the natural seat of the apex when the abnormal movement has held on that side, but this has been comparatively rare. The comparative loudness of the apicial and the basial impulse is most satisfactorily ascertained by employing the differential stethoscope. There is something very striking and suggestive in the fact, that the heart's sounds are heard only or much louder in or through the ear connected with the first or second interspace than in or through the other ear connected with the fifth interspace, the normal seat of greatest heart-sound-intensity.

The sounds of the heart, beyond an increase of intensity, present in general no abnormal or adventitious character. It is true that an arterial murmur is occasionally heard at the first and second interspaces; but this we have remarked is liable to occur in the preceding stages.

It does not appear that serious mechanical impediment occurs in connection with this remarkable condition. I have not found dropsy, local or general, to be more common in these than in other cases. In keeping with this, though the patient is sensible of undue movement, and calls attention to a "beating of the chest," it cannot be said that he suffers material inconvenience from it. I have known many patients highly interested in it after their attention had been called to it for the first time by myself.

This sign is usually associated with other well-marked physical signs, viz., depression of the ribs, usually extensive, dull percussion and dry cavernous voice and respiration. These latter signs may become obscured by the contraction of the pulmonary structure, which indeed favours the sign under consideration by displacement of the heart.

As a diagnostic test I regard this mal-localisation of cardiac impulse as of some material value. In cases not marked by very positive cavernous sounds, as by distinct pectoriloquy, I have often found this sign to give the requisite addition to the evidence to justify the pronounced opinion that a cavity was present. I have never regretted trusting to this sign under some restrictions. Silent old cavities offer the conditions under which this sign is of most value.

The conditions for which this sign may be mistaken are the impulse of aneurisms, the impulse of mediastinal and pulmonary root tumours, and the increased impulse of the highly nervous or excitable heart. The impulse of aneurism is circumscribed, and comparatively forcible and more single, so to speak. It is attended frequently with murmur, or marked with loss of the second sound of the heart, and the general impulse of the body and apex of the heart is greatly increased and diffused; signs of pressure, too, upon the bronchus and œsophagus are generally observed. The moving tumour of aneurism, unless very far advanced, is much more deeply placed than the impulse of the heart in cavities. The impulse of mediastinal tumours, moving under the shock of the heart, is usually slight, obscure, and solid. The impulse of the heart, under temporary excitement, is occasionally found at the second space, particularly on the left side. But the temporary or occasional character of this kind of movement, the general impulse of the whole heart, and the temporarily excited pulse, serve to distinguish it. Besides, this form of impulse is much less superficial than that of cavities.

The mechanism of this sign is obvious. In most cases the heart is simply brought into undue contiguity with the surface of the chest. In cases of material, upward, or lateral displacement, traction by means of the shortenings of fibrinous adhesion, &c., has been in operation. An abnormally full and disturbed condition of the right auricle may likewise tend to the increase of the impulse of the heart.

The frequency of the occurrence of basial impulse at the upper intercostal spaces is very considerable. I find it in a large proportion of cases at the hospital. Of seventeen undoubted cavity cases at present (August 1860) under my care in that institution, eleven, or 64·7 per cent. present this sign.

I had prepared a table to indicate the seat and extent of this sign in the above, together with the seat of cavity and other circumstances; but this table has been mislaid. However, I have this day (January 25th, 1861) examined eleven of my female patients in the hospital, all of whom have cavities, with a view to this inquiry. I find that five, or nearly fifty per cent. of these patients, present the basial heart impulse at the superior intercostal spaces.

Age.	Seat of Impulse.	Seat of Cavity.	General State.
16	2nd Left space.	Left apex.	Hectic.
22	2nd Left space.	Left apex.	Fair health.
21	2nd Left space.	Left apex.	Very ill.
21	2nd Left space.	Left apex.	Ill: in bed.
23	2nd Left space.	Left apex.	Exhausted: hectic.

CHAP. XXXV.

THIRD STAGE—*continued.*

Dimensions of Chest.—Reduction.—Increase.—Vital Capacity.—Table.—Little Value of Spirometer. — Over-development of Veins of Chest. — Increase of inferior Thoracic Artery.—Obliterated Veins.—Fistulous Openings.

The dimensions of the thorax are very generally modified in the third or cavity stage of phthisis. The most common alteration is one of diminution, but we occasionally find also one of increase. If we pass a tape measure from the spine over the diseased side, and carry it to the middle of the sternum at a point on the same level as at the spine, we shall generally discover a deficiency of greater or less extent, varying from one to one and a half inch, compared with the same measurement on the healthy side. The difference occasionally reaches to two inches. The measurement is best performed on a level with, or a little below, the nipple in men, and immediately under the mamma in women.

The reduced dimension is associated with the following physical signs: defective respiration, defective voice, except in the case of cavity at the base, and defective movement, now and then with the amphoric respiration voice and tinkle of perforation, and occasionally, but very rarely, with ægophony in empyema. The anatomical conditions are consolidation and comparative absence of air cells, tubercle and hepatization, moderate empyema, and if we regard perforation as an accident in the third stage, pneumothorax, with only a moderate amount of air in the cavity of the pleura.

The dimensions of the chest at the middle and base are not unfrequently increased in the third stage. An increase of an inch over the healthy side is not uncommon. I yesterday measured a young woman (G. Fruen) in the hospital suffering from a large cavity on the right side. The dimensions of the cavity side were thirteen and a half inches, while that of the healthy side was only twelve inches. The anatomical condition here was tubercular consolidation with serous infiltration.

Empyema is one of the most common causes of increase of the dimensions of the chest in this stage.

I have reason to believe that the lung, enlarged by excessive vascular supply, by serous infiltration, and by deposition of tubercle and lymph, occasionally becomes hypertrophied, or so enlarged as to distend the chest unduly, and to increase the dimensions of the side. I have frequently seen the lung when taken from the body to be of more than the natural size; and further, I have, on mensuration, found such an increase as that noticed in the case above referred to, to be by no means uncommon, even when no signs whatever of empyema or of perforation could be discovered.

Perforation of the lung, when it gives rise to the presence of much air in the pleura, which cannot be expelled during expiration, causes an excess in the dimensions of the side. I examined a young man (T. Perry) lately in the hospital, labouring under pneumothorax, the dimensions of whose two sides varied considerably. The diseased side (the right) measured 16¼ inches, and the healthy side 15 inches. The other physical signs were, amphoric respiration and amphoric voice over the entire side, with resounding, hollow, or tympanitic percussion sound, chiefly developed at the base, and contrasting greatly with the somewhat dull sound of the base of the non-perforation side. But the dimensions of the chest in pneumothorax, like the other signs of this state, fall to be described under the fourth or perforation stage.

VITAL CAPACITY.—The capacity for air, or the vital capacity, as, with an undue employment of this important adjective, it is called, of the lungs in the third stage of phthisis, is, as a rule, greatly less than that of the first and second stages. But it is not for one moment to be doubted that striking exceptions to this rule now and then present themselves. A case of phthisis in the third stage, marked by a cavity small in size, and with little consolidation in the other parts of the lung, is now and then met with, in which the air capacity is reduced less than holds in a case of phthisis in the first stage, with tubercles well disseminated throughout an entire lung, or with tubercles freely deposited in both apices. A case of phthisis, with extensive softening in the second stage, and with a highly congested and serous state of the more healthy lung, will be marked with more reduction than holds in such a case of the cavity stage which has just been indicated. Yet the general rule holds that the capacity is more diminished in the third than in either of the preceding stages. The amount of reduction varies much, being generally in proportion to the amount of destruction of vesicular lung, of bronchial obstruction, of hepatization, or of liquid in the pleura, whether this be serous or sero-purulent.

The following table exhibits the vital capacity in the third stage of phthisis. The observations are Dr. Hutchinson's:—

Stature.	Capacity in Cavity Stage.
5 feet 0 inch to 5 feet 1 inch.	82 cubic inches.
5 „ 1 „ to 5 „ 2 „	86 „ „
5 „ 2 „ to 5 „ 3 „	89 „ „
5 „ 3 „ to 5 „ 4 „	93 „ „
5 „ 4 „ to 5 „ 5 „	97 „ „
5 „ 5 „ to 5 „ 6 „	100 „ „
5 „ 6 „ to 5 „ 7 „	104 „ „
5 „ 7 „ to 5 „ 8 „	108 „ „
5 „ 8 „ to 5 „ 9 „	112 „ „
5 „ 9 „ to 5 „ 10 „	116 „ „
5 „ 10 „ to 5 „ 11 „	119 „ „
5 „ 11 „ to 6 „ 0 „	123 „ „

The results of numerous observations made upon the third-stage patients in the hospital permit the conclusion that the amount of air expired by them is very much below the average of health. My experience of the spirometer with these patients does not permit me to speak highly of it as a practical method of diagnosis. In the first place, it is somewhat dangerous to cause persons with excavated lungs, many of them in peril of hæmoptysis, to distend the lungs, and then make prolonged expiratory efforts. Persons who have made the necessary efforts have complained days after of various evil results from them. To use the spirometer, even tolerably well, a course of education on the part of the patient is necessary, and long before this has been gone through, the physician may easily discover by other means the precise situation of his patient. Females, with scarcely an exception, render the use of this instrument almost ridiculous. After various efforts and much patient instruction, though suffering from no disease of the lungs, adults will expire the trifling amount of 40 cubic inches. I lately tested two young women; one suffering from cavity and another from bronchitis, and the amount expired by each was only 40 cubic inches. I have been told that Dr. Hutchinson's tables have been formed from observations made upon males only, and that he gave up the question of the vital capacity of females in despair.

MINOR SIGNS.—Before concluding the exploration of the thorax in the third stage of phthisis, I am desirous of referring to certain physical conditions which have attracted little notice, and yet are of not very unfrequent occurrence at this period. I shall first refer to a highly-developed state of the veins of the integuments of the thorax. The veins, as regarded by the eye, present numerous ramifications over the upper front of the chest, extending to the upper part of the arm, and to the neck. The veins are of a highly blue colour, and altogether form a striking object the moment the patient is undressed. I have remarked this condition of the veins most on the affected side, but I cannot say I have ever seen it restricted to it. It is seen pretty frequently. It varies in amount in some cases, attracting very little notice, and in others it is altogether impossible to overlook it. The venation of the surface is not always confined to the front of the chest, but may include the posterior part of the shoulders. In one or two examples I have seen it restricted to the upper and posterior surface of the chest. This venation is generally associated with obvious dyspnœa and obstruction to the passage of the blood through the right ventricle and pulmonary arteries dependent upon the pulmonary disease. The veins are obviously well filled with blood, but are not always dilated. Sometimes, however, they are much swollen and dilated. I may mention, though the observation refers to the neck, that great dilatation is very frequently seen in the external jugular veins. This occurs in one out of about ten cases. I remember observing an example of this extraordinary venation of the surface of the chest, in which I felt almost certain that pulsation existed. It is right to observe that this condition of the veins is by no means restricted to the third stage of phthisis, for I have seen it in the two preceding ones. However, it is more common in the third stage than in any other, and I have therefore treated of it here. I yesterday (January 11, 1861) examined the chest of a young woman in the third stage of phthisis, now in the hospital. No particular venation was observed when she was tranquil, but during cough several veins at the front started into strong relief. They seemed to be filled from above. It is probable that these veins were, till lately, continuously dilated, and that they have ceased to be so from the reduction in the mass of blood consequent upon the advanced stage of the disease.

Two conditions of the arteries and veins of the exterior of the thorax I have occasionally seen in this stage of phthisis, which I deem deserving of notice. The first is an abnormal pulsation of the inferior thoracic artery proceeding from the axilla. The pulsation has been very great in some instances. It has usually been associated with acute pleuritic attacks. The artery, besides pulsating abnormally, has been larger and more prominent than natural. I have not found this state confined to phthisis in the third stage, but it has been more frequently observed in it than in the first and second stages, and I have therefore noticed it in this place.

The other condition is a hard, obliterated state of vein, corresponding to the artery, forming a whipcord-like body, readily felt by the fingers. It is the vein obliterated by inflammation, or by fibrinous deposits, or coagulated blood. It corresponds with the enlarged obliterated veins of the thigh and leg, observed frequently in phthisis, and lately ably discussed by Dr. Cursham before the Medico-Chirurgical Society.

Another remarkable physical condition occasionally found on the exterior of the thorax in the third or cavity stage of phthisis, is a certain fistulous opening communicating with the pleural cavity of the affected side. The opening is small, and barely admits a probe; there oozes from it sero-purulent fluid, more or less constantly. It is found chiefly in the lower lateral region. It is a natural outlet which has been formed when, in consequence of inflammation of the pleura, liquid has been effused. The liquid, not having been removed by absorption, or by paracentesis thoracis, has forced by interstitial absorption an outlet or outlets for itself. I have seen this fistulous opening, vicarious perhaps of the offices of the physician in several cases. It is unnecessary to say that these openings occur only in chronic empyema. It is incumbent, however, upon me to admit, that they are sometimes seen independent of phthisis, and that when occurring in this disease, they are not restricted to the third stage. This subject has been already referred to in treating of the signs of the second stage.

A prominence, or bulging, or hernia-like tumour is sometimes observed at the second and third intercostal spaces during the act of coughing. A circumscribed tumour will form, the size of a pigeon's egg. It is formed of the cavity walls distended with air. It disappears upon the cessation of coughing.

A tumour, the same in its nature, is frequently observed above the clavicle, and at the root of the neck. This tumour attains to greater size than the last mentioned. It comes during a cough, and falls immediately after. I have, however, seen a swelling during coughing, similar in appearance, when no cavity has been present.

CHAP. XXXVI.

THIRD STAGE — *continued.*

The Alterations of the Throat. — Oro-Nasal Passages, Larynx and Trachea.— Voice. — Cough. — Duration of the Third Stage Signs.

THE physical alterations of the oro-nasal passages, the throat, the larynx and trachea, common in the first stage, more common in the second, become in the third more varied, more marked, and altogether more serious, frequently calling for active treatment. It cannot be said that in the diagnosis of phthisis in the third stage, these conditions give material aid, for in general the presence of cavities may be made out with certainty by far more direct and decisive tests applied to the lungs and chest themselves. Nevertheless, it is most important to know what the conditions of the parts named are in this stage of phthisis. These conditions being known to be occasionally associated with, and dependent upon important pulmonary disease, will not permit the very serious error to occur of overlooking the parent disease, simply because the derived and secondary maladies attract attention. It is also possible that these conditions may in some rare and uncommon cases lead the physician to examine the chest, when otherwise that region might remain unexplored. The affections of the throat, secondary though they be, have not very unfrequently led the consumptive patient, for the first time, to consult a physician, the annoyance proceeding from them being often excessive, while the pulmonary disease itself has caused little direct distress. But over and above all this, the argument that it is well to have knowledge and to be well informed, cannot be without force, when we have to deal with such a destructive disease as pulmonary consumption, and with the imperilled health of our fellow-creatures.

In the first part of the third stage of phthisis, the abnormal physical conditions of the parts above indicated, are less frequently observed, and are less severe than in the latter period. It may be stated that in a very small percentage only of patients do we find these parts perfectly healthy. Almost every sufferer in the third stage, who has not been as it were prematurely and early cut off by unusually severe symptoms, by complications such as hæmorrhage, pneumonia, acute pleurisy, and empyema, has presented one or more marked physical alterations of one or more of these parts. The patient dying the usual death of exhausting phthisis, invariably presents diseased conditions of the mouth, tongue, throat, and larynx.

The colour of the cheeks is liable to alterations. The healthy redness of the Anglo-Saxon face, for the most part of the twenty-four hours, is considerably reduced, and a pallor or sallow aspect take its place. This loss of colour is liable to be almost instantly replaced by excessive redness or flushing, under moral excitement, of the slightest character, to remain, however, only a short period.

In highly hectic cases, the colour of the cheeks is greatly heightened at various parts of the day, particularly in the afternoon or evening, and at any time after eating. It has been remarked by some writers that the flushing is more liable to occur, or to be more developed on the cheek corresponding with the side of the chest on which the cavity is situated, and I must admit as a result of a small numerical inquiry which I have made, that the observation is founded in truth.

Of twenty-two patients, of whom eleven are males, and eleven females, now in the hospital, under my care, and suffering from tubercular cavity, fifteen present the following conditions of the voice, gums, &c.:—

Initials.	Sex.	Age.	Morbid Conditions of Voice, &c.	Seat of Cavity.
J. H.	F.	16	Whispering voice	Left.
H. B.	F.	21	Occasional gruffness of voice . .	Left.
M. P.	F.	28	Occasional hoarseness . . .	Left.
S. S.	F.	39	Hoarse and suppressed voice . .	Right.
M. W.	F.	25	Complete aphonia at times . .	Left.
E. M.	F.	33	Aphonia, formerly. Tongue red at tip. Lower gums red	Right.
A. H.	F.	25	Hoarseness	Left.
E. H.	F.	27	Weak voice. Lower gums reddened .	Right.
M. F.	F.	23	Upper and lower gums reddened	Left.
G. S.	M.	34	Aphonia. Tongue red in middle .	Left.
S. A.	M.	19	Dry state of fauces	Right & left.
G. W.	M.	26	Occasional weakness of voice . .	Right.
G. W.	M.	31	Occasional weakness of voice . .	Left.
M. H.	M.	48	Constant hoarseness of voice . .	Left.
G. M.	M.	27	Hoarse voice	Right.

The mucous membrane lining the interior of the cheeks is very frequently found to be over-reddened, due to a state of hyperæmia. The colour is unduly brilliant. The mucous membrane is often a little full, approaching to swelling, and projects where it corresponds with the interspaces of the teeth. Very frequently when the patient is becoming very exhausted, the membrane is found to be aphthous; and in some cases superficial ulceration takes place.

The lips are frequently the seat of morbid conditions. Pallor is the most common state. A brilliant redness and highly injected state are common, particularly in children and in young women. Tumefaction of the lips I have occasionally seen, sometimes attended with ulceration at the angles of the mouth, and on the interior surface corresponding with the teeth. The lower lip is most frequently affected. Eczematous and herpetic states are not uncommon. A girl, about ten years of age, now in the hospital, and suffering from a large pulmonary cavity, has been for several weeks greatly annoyed with an inflammatory, painful and swollen condition of both lips, evidently dependent upon the thoracic disease.

The tongue presents in almost all cases of phthisis, rapidly tending to death, unhealthy physical appearances. Often it is coated with a dense yellow fur, and the papillæ are long, woolly or hairy looking. In many cases the tongue presents spots denuded of epithelium, and as if polished. The entire upper surface of the tongue having been shorn, as it were, of its epithelial covering, is uniformly red and smooth, and raw-like. This deprivation of the epithelium is often sudden. When the tongue has remained some time in this abnormally red and smooth condition, it frequently becomes covered with patches of aphthæ, or the whole surface may be spread over with this white parasitic production, to be occasionally removed in part, and to be soon succeeded by another crop. The tongue, however, remains in some few cases, healthy to the last.

The roof of the mouth is frequently the seat of aphthæ, and is often tender.

The pharynx presents all the conditions mentioned, as occurring in the second stage, and in an aggravated form. I have often seen this part covered with aphthæ, and the seat of so much irritation and pain, as to produce distress and difficulty in the act of swallowing. Pungent medicines, such as ether, are frequently refused by the patient for this reason, and I have known drinks containing only a very small amount of acid to be the source of great annoyance to the patient.

The glottis and the epiglottis are seldom found healthy in the sinking patient. The epiglottis is frequently ulcerated, particularly on its under surface, and on the side corresponding with the most diseased lung. I have seen minute tubercles upon it. The glottis is occasionally ulcerated, and may be felt with the finger to be irregular in consequence. In such cases, distress in swallowing is frequently experienced; and some drops of liquid passing down into the larynx will threaten to destroy life by suffocation. When the glottis is narrowed, suffocation and stridulous respiration sounds are heard to proceed from the parts.

The larynx in many cases of phthisis is much affected. This part often becomes diseased at an early period of the third stage, and few exhausted patients have this part in a state of health. In some cases the signs of this local affection predominate over those of the lung disease, and even serve to mask them for a time. This latter fact gave rise to the erroneous idea of there existing as a not uncommon malady, a purely laryngeal phthisis. The pathological states of the larynx are inflammation more or less acute, ulceration and the deposition of tubercle. These are the more common, but at a later period, in not a few cases, total destruction of the vocal chords and necrosis of the cartilages take place. The physical signs which attend these diseases relate to the voice, the acts of respiration, cough, and the act of swallowing.

The voice at first is rather hoarse, and comparatively indistinct: it becomes weak; before it is pronounced, the patient is observed to hem, and to endeavour to clear the throat of mucus. The weakness increases, and the voice often degenerates into a coarse whisper, and then the affection is called aphonia. This aphonia is sometimes so complete that not a single word is articulated. I remember a man at the hospital who could only make an inarticulate loud noise, and when he became very anxious to speak, he made great efforts, and succeeded in producing only a horrid series of short roars. It was impossible to understand by these efforts what he desired.

The respiratory sounds are stridulous in many cases, the quality seeming to be acquired at the larynx.

These stridulous sounds are loud. The patient upon exertion has this quality intensified, and he then feels as if he might be suffocated. These sounds are often so loud as to mask the presence of very grave disease in the lung. I remember an hospital patient whose laryngeal sounds were so loud as to render for a time all satisfactory exploration of his lungs impossible. He died suffocated, no operation being permissible. I remember also the case of a man who served in an open oyster-shop in Oxford Street, whose laryngeal respiration sounds were so pronounced as successfully to conceal the auscultatory signs of cavity in the lung. All at once, however, amphoric respiration and amphoric tinkle of a large cavity were made out. Notwithstanding all this, the patient continued to open oysters, the shop window unclosed, straining for health, and speaking only in a hoarse whisper.

Moist crackles frequently take place in the larynx, and may be heard at a distance. They often grieve the patient and ruffle his temper.

The cough is stridulous and suffocative, and thus it is with difficulty the morsel of food cautiously dealt with, is ultimately passed down the œsophagus.

The cough of the third stage is generally a source of much annoyance. It is heard in nearly all cases. But I have known not a few patients to be altogether free from it for days and weeks. This circumstance has given them great confidence, and has, in the opinion of some of them, conclusively proven the non-existence of pulmonary disease. This absence is observed in chronic cases progressing favourably. Many patients really have cough, and will even cough in one's presence, yet maintain, in the face of remonstrance from friends, that they have no cough and never had one. In many patients, even in those who are doing pretty well, the cough is loud and frequent. In the exhausting patient, it is generally a great annoyance, constantly causing distress, and during night interfering with his sleep. The cough is generally loud and prolonged; the whole chest is strongly compressed, and it is repeated several times before the patient is relieved. Much sputum is generally brought up; this being yellow or green mucus, and pus with or without blood. Sometimes the sputum is clear and glairy, and contains some bubbles of air. This is most observed when there is acute inflammatory action.

The duration of the signs of the third stage is a very variable period. In chronic cases which do well they, or some of them, may continue even ten or twenty years. I have known a man bring up cretaceous formations during a period of some twenty years. This, however, is not the usual duration. Most patients who die in the third stage have not had the signs, there is good reason to believe, above two or three years. In a large number of cases the duration is about six months. In not a few acute cases, in cases marked by hereditary tendency, and in cases in which the patient either will not take care of himself, or is incapable of having the comforts of life, the means of warmth and nutriment, and the advantages of medical advice, the period of the physical signs is not more than a few weeks.

An abatement of the third-stage signs frequently takes place for a time.

The comforts of home, the attendance of a good nurse, the genial climate and medical aid, even the efforts of nature nearly unaided, serve occasionally to dismiss some signs and abate others. Three months' residence in the Hospital for Consumption I have known to effect these results in numerous examples of the disease in its third stage.

The termination of the third-stage signs are threefold. In some few favoured patients they terminate in the restored health and the modified signs of obliterated cavity, &c.; in the great majority death concludes the signs and the patient's hopes and sufferings; in a considerable number, the signs terminate in the fourth stage or perforation period.

CHAP. XXXVII.

FOURTH OR PERFORATION STAGE.

Physical Signs. — Tympanitic Percussion Sound. — Dull Percussion from Effusion. — Amphoric Respiration. — Signs of Third Stage abated. — Compared with Cavity amphoric Sounds.

Phthisis has usually been divided into three stages, but I believe that the course I have decided to adopt in dividing this malady into four stages is more agreeable with the natural history of the complaint. Excavation, which is the characteristic of the third stage, tends to progress, and the progression of excavation naturally tends to the penetration or perforation of the pleura. But for pleural adhesions in the third stage perforation would be almost unavoidable. Perforation is a natural consequence of progressive excavation. This is more than can be said of empyema, excepting in dependence upon perforation, for it is more an adjunct to, or a complication of, the disease. There is no unavoidable tendency to simple empyema. But it is otherwise with perforation in the case of progressive phthisis. The progress of a cavity is to the surface. But putting aside mere tendency, let us inquire into actualities. I am satisfied that perforation actually occurs in a very considerable proportion of advanced or old standing cases of phthisis. I have met with many examples of perforation, and besides, I have every conviction that cases constantly occur without their being recognised. Perforation is an accident which occurs only or chiefly when the patient is very ill, and generally long after softening or cavity has been diagnosticated. The patient's disease is so well known that, in the extreme end of his sufferings, examination is not thought to be essential; and again, the exhaustion, the helplessness, the breathlessness, the agony, and the apparently near dissolution of the sufferer, argue with the physician for non-disturbance and for quietude. The frequency of perforation has lately been much brought before me. At the moment at which I write (Sept. 25th, 1860) I have in the hospital two patients,—one a young woman 15 years of age (Weare), another a young man (Perry) about 22, suffering the agonies of perforation. It was only this afternoon that I examined the perforated lung of a patient who died of pneumothorax a day or two ago. Two patients out of seventeen suffering from cavity in the lungs, at present under my care, give a large percentage viz. 11·7. This percentage is doubtless above the average, but I am satisfied that it is not, what many physicians will believe it, very *greatly* above it. This rate of frequency much exceeds that which holds with cavity cases at an early period. It is to be borne in mind that cavity cases, on the whole, are seen at a late stage in the hospital, and that not a few patients are admitted in an almost moribund condition.

Before leaving the subject of the frequency of perforation, I would add, that if we look at the deaths from phthisis in its three accepted stages, and compare them with the deaths from perforation, the latter condition assumes great prominence. Since October 1860, I have had four deaths among my female hospital patients, and two, or fifty per cent. of them, occurred in the perforation period. During the same time I have had seven deaths amongst my male hospital patients, and one occurred during the perforation period. In private practice two deaths have occurred since August under my own eye, from perforation. What rate these bear to the total number of phthisical persons who have consulted me privately, and who have since died, I am unable to say; for comparatively few results are communicated; but it must be considerable. (Jan. 28, 1861.)

Further, I would submit, that during the time I have been full physician to the hospital, several cases have occurred which, though I could not positively say were perforation cases, yet presented highly suggestive signs of pneumothorax, such as obscure amphoric respiration and tinkle.

The physical signs of the fourth or perforation stage are very remarkable and interesting. A greater difference holds between these signs and those of other stages of phthisis than between those of any two of the other stages. The most conspicuous signs of the fourth stage, in reference to auscultation and percussion, are absolutely new, and not a mere increase of those of another stage. They take the place to a large amount of the signs of the third stage, to which they suddenly cause a cessation or bring an abatement.

The physical signs of phthisis in its fourth stage are so different from those observed in the previous course of the disease, that on this account it is not only natural, but very conducive to the avoidance of important errors in diagnosis, and even to the very discovery of the nature of the disease itself, that a broad line of demarcation should be established between this and the preceding period of the malady. To continue to treat this period as an accidental condition of the third stage is assuredly not consistent with the novelty and importance, and even antagonism, of the new signs, and with the marked alteration in the morbid anatomy upon which they depend, and with the sudden access of most distressing symptoms.

The formation of a new stage, that of perforation, will serve beneficially to call more particular attention to the accident of perforation, and to cause this condition to be better studied, to be more looked for, and, I am convinced, to be less frequently altogether overlooked.

The clearness or the extraordinary air character of the percussion sound which attends this stage, is so different from the dull percussion almost universally associated in the mind of the medical practitioner with pulmonary consumption, that when his first visit is made to a patient in the fourth stage, he is liable to conclude that the lungs are sound, that no disease is present in these organs, and that careful auscultation is totally unnecessary. He internally says, "Oh, what fine percussion!" I am convinced that the clearness and fulness of percussion sound, so different from the short flat sound believed to be almost inseparable from phthisis, has on numerous occasions led to the conclusion that the chest need not be auscultated, even when the perforation or last stage of phthisis had arrived, and the patient has been within a few days or hours of his dissolution. I have very lately met with such an example. The attendant, patting the thorax and exclaiming "plenty of air here,"—is apt to imagine that the underlying and compressed lung is more than usually healthy.

PERCUSSION IN THE PERFORATION STAGE OF PHTHISIS.—The percussion sound of the thorax in the fourth stage is remarkable for loudness, extent of area, air quality, and hollow drum-like character. When the chest is struck, the whole side seems to give out, and does give out, a loud, sonorous, almost musical note. The note seems to proceed from full vibrations of the entire ribs, and all the contained parts. The side may be felt to vibrate at the same moment. The sound is drum-like, and has therefore been called tympanitic. It is a full, large-volume sound, and seems to fill the room, if a small one, in which the percussion is performed.

The sound is obtained from the percussion of every and any part of the perforation side, from the clavicle down to the rib corresponding with the very base of the lung anteriorly, laterally, and posteriorly, at first, or until air is absorbed or liquid is formed. Inferiorly, the percussion clear and resonant sound is obtained beyond this, and the tympanitic percussion of the left side may descend so low as to mingle with the tympanitic percussion sound of the stomach. On the right side, instead of a dull percussion sound from the region of the liver, we often have a clear or even a tympanitic sound. The resonance is fullest, for the most part, over the middle and base of the chest. It is below the angle of the scapula, in the lateral region and in the mammary region, that the fullest amount of resonance or air quality is obtained. It is at the apex of the chest, above the clavicle, at the clavicle and below it, that the fulness or resonance is least developed. After lasting some days, or weeks, the resonance is liable to become diminished at the base of the chest, and even to be replaced by dulness: this occurs upon the supervention of effusion, and the abatement of resonance and the replacement of it by dulness are proportionate to the amount of the serum or sero-purulent liquid contained in the pleura. In general, a very considerable amount of effusion is necessary very sensibly to modify the resonant and tympanitic character of the percussion sound of the perforation stage of phthisis.

The presence of six ounces of liquid, which I lately found in the chest of a female (Farrell) who died of perforation, had been altogether inoperative in reducing the air character of the percussion note.

The tympanitic percussion sound alters with the progress of the perforation stage. In general, at the very first it is decidedly appreciable; in a few days it is highly pronounced, being elicited from all parts or nearly all parts of the affected side; in the course of some weeks it generally happens that some degree of dulness is found in the lower dorsal and lateral regions from the presence of effusion. Again, after a very considerable lapse of time the general resonance may become gradually reduced, and continue to reduce until it is scarcely appreciable, this occurring when the perforation is contracting or contracted, and when the pleural air is being reduced by absorption.

Sometimes the tympanitic resonance is to be obtained at its highest degree immediately after the occurrence of perforation signalized by great distress. At other times I have reason to believe, perforation occurring, the aperture being small, and very little air being admitted into the cavity of the pleura, that the resonance is only very moderately increased, and so little marked as to cause in itself no suspicion of perforation. I have in some examples of the perforation stage of phthisis found the resonance only moderately increased beyond the normal degree, and at a time when I have been able to hear undoubted pleural cavity respiration and voice, i. e. amphoric respiration and blowing, and also amphoric voice.

In some examples of perforation, no abnormal resonance is heard on percussing the clavicular regions, and some degree of dulness may be obtained as low as the level of the upper border of the third rib. This occurs when the adhesions are extensive, firmly binding the thoracic walls, and so complete as to prevent air getting between the apex of the lung and the walls of the thorax. But it is right to observe that increased resonance is not excluded from parts under which adhesions exist. The air, if in great quantity, in the vicinity serves to produce even over adherent parts undue resonance to some moderate extent.

The tympanitic character of the percussion sound, it may seem needless to say, increases with the accumulation of air in the pleura, and abates with the reduction of the volume of that fluid by absorption.

The tympanitic percussion of perforation is sudden in its access. The physician, after having heard the usual dull sound at one visit, will on his next be struck by finding no dulness, but, on the contrary, a clear sound, more so than on the healthy or the non-perforated side. This will perplex him if he do not call to mind the liability to perforation, and if he should fail to discover the usual reputed signs of perforation, viz. amphoric blowing and metallic tinkle. I lately examined a young female in the hospital suffering from numerous cavernules. The percussion sound on her admission was dull all over the posterior surface of the chest, and it was distinctly so recorded. A few days after the percussion sound was found greatly altered, being exceedingly resonant on one side and less so on the other. I began to doubt the correctness of the first observation, as none of the other usual signs of perforation were obtained; but my doubt was dissipated a few days after by finding very loud amphoric blowing on the more resonant side. This patient died. Two perforations were found, recent lymph covered the pleura, but no effusion had formed.

The tympanitic percussion due to perforation, in my experience, and I believe in that recorded by others, has been generally confined to one side. By means of the restriction of tympanitic resonance to one side of the chest, the contrast is soon made out, and the true nature of the internal condition is appreciated.

Increased resonance, approaching to tympanitic sound, however, occasionally does hold on the non-perforated side, and takes its origin in part from the air on the opposite side. The clear resonance in this case on the non-perforated side is less general, and is manifested chiefly near the sternum and the spine. That such abnormally resonant sound is produceable in this manner I am fully assured. In the case of the young female, above referred to, an abnormally resonant note held on the healthy side. Death occurred; and it was only on one side that perforation and pneumothorax existed, as was ascertained on the post-mortem examination. The resonance of the sound side proceeds in a great measure from the air contained in the opposite side.

Tympanitic percussion sound of perforation is generally accompanied with other signs declaratory of the accident or event. I may say that in every example other signs must have existed at one time or another. But on the other hand, tympanitic percussion sound may be present for a time and at an examination without other signs being pronounced. So generally is the form of percussion associated with amphoric respiration or voice, with metallic tinkle ranging over a great area, with splashing sounds, and comparative immobility, that except in an exceptional case, which one has some little difficulty in conceiving, I should be disposed to regard tympanitic resonance, though highly suspicious, as inconclusive of the presence of perforation without the corroboration of one or more of these other signs. Making this restriction, I have no hesitation in saying, that amphoric respiration is often absent for a time when perforation has occurred, and is denoted only by tympanitic percussion. The practical lesson to be taken from this is, not hurriedly to conclude that tympanitic percussion sound is necessarily non-perforation in its origin, because amphoric bruits cannot be heard at our first examination. When I come to speak of amphoric respiration, it will be seen that it is not always persistent, and is seldom uniform in intensity and force for many days together; but, on the contrary, is variable in itself and in its associated signs. The percussion note is of a constant character; no material change is perceived to take place from day to day. When the resonance becomes impaired, it does so, gradually giving place to a healthy sound, or the absolute dulness of empyema.

While the greater part of the side, the perforated side, gives to the percussion stroke a tympanitic answer, in general, dulness, but somewhat qualified, continues at the clavicle, and above. This circumstance depends upon the presence of adhesions, and the extent of retained dulness will depend upon the greater or lesser extent of the abnormal union which has taken place.

The mechanism of tympanitic percussion sound is obvious. It is due to air in the pleural cavity. This permits the solid walls of the chest to vibrate fully and freely and extensively, and for a long period. The sonorous vibrations being free from pressure and impediment run throughout the whole length and breadth of the side; they are propagated in the pleural cavity, and reflected back and forward, causing a prolonged sound. The vibrating chords, so to speak, are long, and accordingly emit grave prolonged sounds, the reverse of what occurs in the case of short chords, which emit short, acute, or short duration sounds.

The bruit de pot fêlé sound, or cracked-pot clink, I have never heard in the fourth or perforation stage of phthisis. It does not seem to be continued on from the third to the fourth stage. The presence of air in the pleural cavity probably suffices so to compress the cavity as to present a sufficiency of air quoad this peculiar sound. The air exterior to the cavity will receive the percussion stroke, and oppose the origination of the sign. When the air in the pleural cavity is totally absorbed, and the patient continues to live, I see no reason why the bruit de pot fêlé sound should not return.

The ordinary dull percussion sound at the clavicular region I have found to return in a few examples of phthisis in which perforation had taken place. This is effected by the removal by absorption of the contained air. I believe that absorption of a considerable amount of air cannot take place to that extent as to reproduce full dulness under some two or three weeks. With this reproduction, the tympanitic resonance in other parts is materially reduced. Together with the absorption necessary to these results, it is essential that the further admission of air be prevented, at least for the time, into the pleural cavity.

The duration of tympanitic resonance, with its accessories, is, on the whole, of short duration, being that of course of the perforation stage, which is usually short. A month is a common term; but I have known it certainly to endure with more or less variation and intensity for about a year. Of this I have not the smallest doubt, and I shall refer to this subject when I speak of amphoric respiration sounds.

The termination of tympanitic percussion is observed in some few examples of the fourth stage in the restored dulness of the third stage. I have seen examples of this. In a considerable proportion it never ceases during life, and may be heard even after death. This occurs when no effusion takes place, or when liquid forms in only moderate amount.

The tympanitic resonance terminates, in many cases, in the development of a very different sound, viz. absolute dulness at the more dependent parts of the side, and in the restriction of itself to a small portion of the side, that always being the uppermost. This takes place when much liquid forms; the liquid gravitates to the most dependent parts, and the air rises to the most elevated.

The presence of liquid in the pleura, the consequence generally of pleuritis caused by the entrance of air, and of discharge through the perforation, on the whole, reduces the tympanitic percussion sound less than we would at first expect. A moderate amount of effusion is generally present after a week or two; but this will fail to cause dulness, or even a sensible reduction of the hollow or drum-like sound. Effusion to the extent of twenty ounces may be present; and even at a careful examination, such as patients can bear who are very ill, as those affected with perforation generally are, no very appreciable dulness may be discovered. I have known forty ounces of sero-purulent liquid present, and yet the tympanitic sound of perforation has been fully audible and procurable from all parts of the thorax. In this case the air was also in large amount. From observations which I have made, I conclude that much liquid is required to counteract the presence of air, quoad resonance.

The percussion of the thorax in the fourth stage of phthisis is more valuable and suggestive than in any other.

Amphoric respiration is the characteristic respiration of the fourth or perforation stage of phthisis. As cavernous respiration is the characteristic of the third stage, so amphoric respiration is the peculiar characteristic of the perforation stage. It is very remarkable in its character, very different from the vesicular respiration of health, bronchial respiration or the ordinary forms of cavernous breathing sounds. Yet, as cavernous sounds absent themselves in the third stage, amphoric sounds of respiration may be inaudible for a time.

Amphoric respiration is only imperfectly indicated by its title. It has two essential characteristics, while only one, the amphoric, is suggested by the name. Amphoric respiration is at once a blowing fistulous sound, and a large vibrating cavity sound more or less ranging over one side of the thorax. When the ear is placed upon the perforated side, and the mind earnestly attends, a blowing sound is heard, and it is found to be diffused through a large chamber filled with air. The blowing seems to proceed from an opening or fissure, and to pass into the pleural chamber, and range throughout it. It much resembles the sound which we hear when the lips, being loosely applied to the mouth of a bottle with a small neck, air is gently blown into the interior of the vessel. In this experiment two sounds are heard, viz. the bottle-neck or narrow-opening sound, and the reflected or resonant and consonating glass wall sound of a somewhat metallic character, or, indeed, of what it really is, a glass sound. In the case of amphoric respiration of phthisis, the neck through which air passes is the aperture in the cavity wall, including its pleural lining, and the chamber is the pleural cavity filled with air, and covered in with its rather firm, smooth, and sound-producing consonating walls, the thoracic walls.

The amphoric sound of air passing into, and out of, the pleural cavity through a fistulous opening in the cavity walls, though always of a blowing nature, varies a good deal in intensity and even in character, in different cases, and at different examinations in the same case. In some cases it is faint, and heard only with the aid of great attention: it is gently blowing as if the air met with only little resistance; in other cases it is harsh and loud, and an impression is conveyed as if the air passed into the pleural cavity with some force and compression, and, so to speak, with an escapement bruit.

In the same patients the amphoric blowing is heard nearly of an uniform strength and character at different examinations; in some it varies greatly. In cases about to terminate fatally, the resonant blowing is usually loud and diffused. In some patients the sound becomes inaudible for a time,—hours, or, less frequently, days. I have been unable to hear it for weeks, and then it has returned, quasi-vesicular, or bronchial or cavernulous sounds taking its place, and seeming to come more or less from a distance.

The varieties of the character of amphoric respiration sounds depend much upon the various kinds of openings which are made into the pleural cavity. An aperture, the size of a coriander seed,—and we see such,—will produce generally a small and an occasional sound only, for the friction will be slight, and the orifice may be closed from time to time by secreted fluids. A considerable slit or chink-like orifice will produce more of the fine bottle-neck character, while such a rent, an inch long, such as I witnessed a day or two ago, will certainly bestow upon the amphoric sound a coarse blowing character.

Amphoric blowing sounds accompany both inspiration and expiration in general. In some examples of faint sound it has been heard only during inspiration, and in a very few examples only during a forced inspiration. It is usually stronger during inspiration than during expiration; but I lately met an example of perforation in which the amphoric blowing was decidedly loudest during expiration. In this case (Perry), examination after death revealed a large aperture and forty ounces of liquid. In another case (Farrell) sometimes the amphoric sounds were loudest during one act and sometimes during the other.

Forced inspiration will occasionally reveal to the ear of the auscultator this most significant sign in cases in which, during the ordinary respiratory efforts, the sound is not appreciable. In suspected examples of perforation, in which, during ordinary respiration, no amphoric sound is heard, the patient should be directed to breathe deep.

I have personal experience of the necessity of attending to this caution.

In some examples of perforation, the auscultatory sounds are less developed at first than at a succeeding period. I feel convinced that I have seen a case of perforation in which no amphoric respiration or voice sounds could be made out, but in which the advent of tympanitic percussion and extraordinary respiratory distress and exhaustion have suggested this accident. I lately saw a young gentleman in an almost dying state, in whom respiratory sounds were heard equally, or nearly so, on both sides of the chest, by means of my differential stethoscope. Some moist crepitation was heard, and percussion was unduly resonant on the right. A month after this, amphoric respiration and tinkle, or bubble sound, were manifest on this side. The general distress was the same on both examinations. The aperture was small at first; afterwards was large and permanently patent. This patient died.

In many examples of perforation, amphoric blowing sounds are heard over every part of the perforated side. In such cases I have generally found the sound loudest posteriorly at the scapular region, and immediately beneath it. I have also heard it very loud at the second costal cartilage. As a rule, amphoric blowing sound is heard more distinctly posteriorly than anteriorly. In a few examples the amphoric blowing is confined to a small locality. I have heard it in some cases only at the region of the spine of the scapula. In other cases I have heard it in decided intensity only at the scapular region, that is, between the spine and the angle. In the cases of those examples of restricted amphoric sound, the sign is always feeble. In all the examples of amphoric blowing sound which have come lately under my care, it has been heard in every part of the perforation side, below the level of the spine of the scapula behind and of the second rib in front.

Direct amphoric blowing has in my experience been confined to one side of the chest only, in the same patient. I have, however, heard faint and distant amphoric sounds extending from the diseased side, a little beyond the border of the sternum of the opposite side.

Of six cases of perforation, which I have lately seen, three occurred upon the right, and three upon the left side. Perforation appears to have no *real* preference for either side.

The auditory signs of the second and third stages of phthisis are liable to be eclipsed and extinguished by the advent of perforation. Cavernous sounds become either lost or are much reduced in extent, quoad area. The moist sounds of the lung in the second stage as a rule are lost, quoad the middle and the base of the lung. But in most examples of amphoric blowing, moist sounds, if they existed at the moment of the occurrence of perforation, continue to be heard at the very summit of the lung, i.e. at the supra-clavicular region and the supra-scapular region. In the young man (Perry) in the hospital, now suffering from perforation of the right side, a very great amount of large liquid or cavernulous bubbling is heard at these regions. In another case, viz. that of a man of twenty years of age, much liquid crepitation was heard at the right scapular region. In some cases it is not till perforation has existed some days or weeks that the third stage signs are materially reduced.

During the presence of the amphoric respiration of perforation, little or no lung or bronchial sounds are heard over the middle or base of the perforated lung. Compared with the sound of ordinary respiration, or the sound of phthisical respiration of the preceding stages, that of the perforation stage is in many cases feeble; but in not a few cases it is loud and blowing.

Sometimes we hear a blowing sound coming from a distance, and diffused in a large empty space, so to speak, occasionally relieved by a metallic tinkle, proceeding from the rupture of a bubble, and coming generally at the rate of one with each inspiration. I have on one occasion heard a little distinct liquid crepitation posteriorly and near the base, which I attributed to an unusual contiguity of the lung from the presence of adhesions operating to maintain the base of the lung comparatively *in situ*. Sometimes the blowing is loud and resounding, as in a vault, with several tinkles with each inspiration, and there is tinkling expiration.

Between the amphoric sound of inspiration and that of expiration there is often a distinct pause, or period of silence, greater than holds between the sounds of healthy inspiration and expiration. The expiration blowing is usually shorter than that of inspiration. The inspiration is generally louder than expiration, but I have witnessed the contrary. In some cases, the amphoric blowing is continuous, no pause occurring at the end of inspiration or of expiration. This occurs when the opening is large. Continuous sighing is heard in the case of Thomas Perry, aged twenty-one years, now (Oct. 2, 1860) in the hospital, suffering from perforation of the right lung. No interval whatever is observed, the inspiration sound is louder and coarser than the expiration one, and the sound falls to its lowest point towards the close of the expiratory act.

The remarkable difference between the amphoric, weak, empty-blowing sounds of the perforation side in some cases is well conveyed to the mind by the use of the differential stethoscope. On the healthy side we hear full, perhaps puerile and prolonged respiration, at the same moment that we are made sensible of the empty, vault-like blowing of perforation, often associated with single metallic tinkle, i.e. with a single tinkle to each inspiration.

The amphoric blowing of perforation is imitated, or rather approached, in character by only one sign of any other morbid condition. This is the amphoric blowing of large dry cavities filled with air. The bottle-neck element in this form of amphoric sound is generally less developed, and the chamber quality is much restricted in area. The metallic quality or tone is occasionally complete. The pulmonary cavity amphoric blowing is restricted in space; it is almost confined to those portions of the chest above the level of the fourth rib. It is always accompanied by pectoriloquy. Even the whispered voice is spoken into the ear with great distinctness, and it sounds as if proceeding from the very integuments. The percussion is dull. A hollow quality is sometimes observed; but this is totally different from the full running and vibrating sound of pleural amphoric resonance. Respiration sounds more or less unhealthy are almost invariably heard at the base, in the mere pulmonary cavity case, and the percussion there is deficient in resonance. I have occasionally heard a metallic tinkle, with the amphoric sound of mere cavity, but it had not the full range of that of perforation tinkle.

CHAP. XXXVIII.

FOURTH OR PERFORATION STAGE — *continued.*

Metallic Tinkle. — Seats. — Mechanism. — Splashing Sounds. — Vocal Resonance. — Vocal Fremitus.

METALLIC tinkle sound is the next most important auscultatory or respiration sign in the stage of perforation. It resembles the sound made by a small, but not very small bubble bursting into or in a narrow-necked jar, such as an ewer, a bottle, or a distended dry bladder. It may be made familiar to the mind by shaking up liquid in a decanter, and listening to the bottle as the bubbles burst, by means of a flexible stethoscope and a bag of water or hydrophone placed between the bottle and the object extremity of the stethoscope.

Sounds obtained in this way are less loud than those heard in the perforated lung, but the metallic tone or quality is exact. The metallic quality of perforation is well imitated by the sound of effervescence in a large bottle or decanter, into which carbonate of soda and citric acid are introduced; but the bubbles in this case are too fine to produce the full-sized tinkle of perforation. The same metallic quality I have lately obtained by causing effervescence to take place in the pleural cavity. This effervescence was produced by throwing in successively soda and citric acid. But the tinkle of perforation is still better imitated by placing the lips immediately over, not upon, the mouth of an empty decanter, wetting them with saliva, slowly separating them so as to form a saliva membrane, so to speak, and then bursting it by further separation of the lips.

The tinkle is usually heard singly, that is, only one at a time. In some cases it has been confined to the act of inspiration, and has not been heard during expiration, or in the intervals between inspiration and expiration, or between expiration and inspiration. Successive tinkles during the same inspiration I have occasionally heard. The sound appears to proceed from the successive bursting of several bubbles, either at the same place or at various parts of the lung's surface. I have carefully examined Perry now in the hospital, with respect to this point, and I distinctly find that the tinkle is single; that one occurs during each inspiration, and that they are all alike and uniform in size, so to speak, strength, diffusion and character. A strong inspiration slightly increases the strength and loudness of the tinkle. I thus describe the character of Perry's case, that I may in my description avoid the possible errors of forgetfulness. In short, a portrait from life has less chance of inaccuracy than one drawn from memory. I have in some cases heard tinkling during expiration. During the act of coughing, too, I have heard numerous tinkles together at the lower part of the chest. In a late case (Farrell) the tinkling was copious, and resembled the tinkling of the bells of a sledge. I called it sledge tinkling.

The tinkle of perforation is generally present without intermission, in perforation of recent occurrence. When perforation has occurred recently, I have generally found this sign. When the patient is dying, it has been always discovered in my examinations. When the pleura becomes considerably filled with liquid, the character of diffusion and range is somewhat, only somewhat, reduced, and this of course holds most towards the end of the stage when the effusion is great. When perforation becomes chronic, and the patient lives long, which is occasionally the case, the tinkle may cease for a time, just as the amphoric blowing may do, and this I am disposed to believe, though I am by no means certain of it, depends upon the closure of the aperture, it may be temporary, either by cicatrization or by occlusion, by means of lymph or of mucus. In the case of a man about thirty, named Rees, who lived a year after perforation was ascertained to have occurred, both the amphoric blowing and the metallic tinkle were absent for weeks or months. The tinkle, as well as the blowing amphoric sounds, were heard a year before death, and also immediately before it. This statement does not rest altogether upon my own skill. The patient was pronounced to be affected with perforation by my colleague, Dr. Pollock, who saw the patient for me when I was ailing, and my opinion of the case had not been communicated to that physician.

The metallic tinkle of perforation is usually best heard between the middle and the base of the lung, and posteriorly and laterally. I have found a point immediately below the angle of the scapula a common seat of this sign in greatest intensity. The infra-axillary region, too, often offers the sound in force. It was heard very distinctly above the third rib anteriorly in the cases of the woman Farrell, and of a lady who lately died in the country.

This tinkling sign of perforation is always associated with amphoric respiration sounds, and with tympanitic percussion sound. When amphoric blowing sounds cease, tinkle ceases also, at least, in my experience.

The tinkle of *cavities* is of moderate range, and is usually seated above the third rib. It has less diffused ringing character, and is not associated with tympanitic percussion, though the percussion sound may have a short hollow character, but entirely free from full vibration of the ribs and solid parts. The diffused amphoric respiration sounds throughout the side of perforation are absent.

The mechanism of tinkling seems to be this. An air-bubble forms and bursts. The bursting is attended with an explosion sound. This taking place in a confined cavity the sound is comparatively preserved from decay. The air thrown into vibrations communicates them to the firm and hard exterior thoracic walls. The bubble gives the explosion sound, and the hard thoracic walls, in contact with air and in free vibration, impart the metallic character. The seat of the bubble whose explosion causes the tinkle is, perhaps, twofold. It may be, and is usually believed to be, the surface of liquid contained, it may be in small amount, at the bottom of the pleural cavity, and it may be at the seat of the abnormal aperture. The former seat must be confined to those cases, of course, in which liquid is present, which is found only when perforation has existed some days or weeks. When the liquid is fermenting, and when agitation of the liquid, as in succussion and during coughing, has taken place, bubbles may form at the surface, and give rise to the metallic tinkle under treatment. It is, however, difficult to believe that the sound is often produced by this form of bubble bursting. In such a case there must in the first place be liquid, and in the second, it seems difficult to conceive that only one bubble could be exploded under such circumstances. It seems unavoidable that many small bubbles would form, and that they would continue to explode and impart a constant succession of small tinkles. Now this is not the usual case, for, as we have already said, the tinkle is single in many examples, and comes at the rate of one to each inspiration.

Without presuming to say that tinkling is seldom thus induced, I am inclined to believe that it more commonly proceeds from bubble explosion, or liquid membrane rupture at the fistulous opening, or in its immediate vicinity. That metallic tinkle is not necessarily dependant upon the presence of effusion, is established by this sign being fully developed in the case of a young woman (Weare) who died some weeks back in the hospital. On examination after death no liquid whatever was found.

The ordinary seat of bubble bursting, I believe, is the abnormal apertures in the lung and pleura itself. There we have almost constantly the conditions essential to the formation of bubbles. Indeed the conditions are such that the formation of bubbles is unavoidable. We have liquid enough to form bubbles or membranes in the cavity of the lung. Air is drawn through the cavity and apertures, and will come in contact with the liquid. A bubble or vesicle will form, and the air being further drawn in the direction of the pleural orifice will explode. Probably the bubble is usually formed on the pleural surface of the aperture, but it seems possible that the tinkling rupture may take place in the cavity itself, or in the fistulous passage. If the opening be free, there seems no difficulty in conceiving that an explosion in the cavity, and near the fistulous opening, may produce the ringing tinkle in the pleural cavity. This mechanism may be imitated, as before stated, in this way: the wetted lips in apposition placed over the mouth of a decanter, now separated, the liquid between the lips is drawn out into a membrane, so to speak; a rupture takes place, and a metallic tinkle is heard. I find that if the liquid which ruptures be thick and tenacious it causes a louder sound than water. Now the liquid in cavities, composed of mucus and pus and blood, is thick and tenacious, and is well calculated to form bubbles which on explosion will impart a loud noise.

Bubbles, it is to be observed, formed at the orifice, may slide down to the more dependent parts and explode there. It is worthy of mention, that when examining the body of Farrell, a few days ago, I found a bubble the size of a pea about an inch below the level of the orifice. It lay like a pearl on the lung, set as it were in the coating of pus which covered the compressed pulmonary structure.

But why does the tinkle sometimes confine itself to the act of inspiration? In inspiration, the current of air is directed to the pleural cavity, the bubble is drawn in the same direction, and the solid parts upon which it rests are free to vibrate. In expiration the aperture will be less patent, the bubble may attach itself to the walls of the passage or of the cavity, and may not burst at all; but if it does, it will be with a sound free from the metallic character, as it takes place in a small chamber, and the parts are less free to vibrate. Besides, the current of air being in the direction opposite to the thoracic walls and towards the trachea, the sound will be directed less towards the pleural cavity. In inspiration the explosion takes place towards the larger or pleural cavity; in expiration it takes place towards the smaller and compressed or pulmonary cavity.

It is common, in works on diseases of the chest, to find metallic tinkle assigned to water or liquid dropping in the chest itself. I presume the drop is supposed to fall from the lung above; and it is believed to drop into the liquid below. What evidence there is of liquid thus dropping amounts to almost nil. It seems more natural to suppose that liquid above, when sufficient to form drops, would simply trickle down an inclined surface to the mass of liquid below. Besides, tinkle is heard when no effusion is present. But those who have ascribed the sound to this movement seem to have thought little on the subject, and have been content to follow the dictum of their predecessors. Nevertheless, that so unlikely an accident should be duly signalized, the imposing and beautiful title of gutta cadens has been accorded to it. In this matter I conceive that the authority of names, rather than the weight of facts, has been in operation.

The extent of metallic tinkle will depend much upon the size of the orifice, and upon the dry or moist condition of the cavity, and on the presence of effusion. When the cavity is supplied with much secretion, bubbles will probably form in numbers; when the orifice is dry there may be simply one tinkle arising from the separation of the merely moist lips of the aperture. A large orifice will be more favourable to a multiplicity of tinkles than a small one. Effusion to a moderate extent will of course favour the production of many bubbles.

A sound as of water splashing is occasionally heard in perforation. It becomes audible only some weeks after the occurrence of the perforation. It is confined to cases in which liquid has formed in the pleural cavity, generally in consequence of inflammatory action of the pleura. The sound proceeds from the violent collision of a considerable mass of liquid with air, as in ordinary splashing. It is heard only when the chest of the patient is suddenly and violently shaken, as in the exploratory act, termed by physicians succussion. To practise this, the chest is held by the two hands suddenly moved from the physician, and as abruptly moved or jerked back again. One physician moves the chest while another listens.

Splashing is heard loudest over the middle and base of the pleural cavity. When absorption of the liquid takes place, which is rare, splashing sounds cease. They generally continue to be heard to the last if sought for; but the distressed condition of the patient should make observations of this sound very infrequent. The sound is best heard either with the naked ear on the chest, or with a flexible stethoscope with the self-adjustment of Camman's instrument. I have never heard this sound without placing the ear, either directly or by means of a stethoscope, upon the chest; but Dr. Cotton says he has heard it without this condition being observed.

I should perhaps say I have not purposely sought to detect this sound coming through the air. It is more a curious sound than one of diagnostic value. Still it is desirable that the auscultator should know that it occasionally occurs, and that he should have once heard it. When it occurs, the case is amply denoted by other signs, and death is not far off. The instance of its greatest development that I have met with occurred in the hospital a few weeks ago. The patient (a young man) was Dr. Cotton's. He was removed from the hospital in a dying state. It requires some amount of effusion to produce splashing. After death I succussed a body without eliciting this sound, and I found six ounces of pus in the pleura.

The splashing sounds are not to be frequently sought for. When they are to be discovered the patient is generally, almost always, extremely ill and impatient of exertion or handling, and they (the sounds) are not to be heard without the employment of considerable violence. Humanity then will prevent repeated searches for the splashing sound sign.

The presence of air and liquid, abrupt motion,—resisted,—and a closed cavity, are the conditions which lead to the production of this acoustic sign.

If the liquid be thick pus, it would probably be difficult to obtain this sign. In the case above related, in which no sound could be obtained after death, the liquid was thick.

The vocal resonance of the chest is variously affected in the perforation stage of phthisis. In some cases it is reduced, in others it is augmented. I believe it has usually been regarded by auscultators as reduced in this stage. I have lately paid some attention to this subject, and in all the examples of perforation which have recently come under my observation, and specially examined for the vocal sign, the voice has been augmented. Besides an alteration in the force or intensity of the voice, we discover other qualities which are new. The voice acquires a blowing character, as if it came from a pipe or narrow aperture. The voice has a metallic quality and large area-ring. This may be called glass quality as well as metallic. It might even be called membranous, for a distended closed membrane gives out this tone. Besides these alterations, we discover a quality which indicates great diffusion in a chamber with reflecting walls, and containing air. This quality is always associated with the presence of air, and this body is always suggested to the mind of the physician acquainted experimentally with acoustics, when he hears the pneumothorax voice. The presence of liquid in the pleura is not essential to the production of this peculiar voice, nor indeed to any metallic sounds whatever. Effusion does not even intensify these sounds, and if it went far it would impair them. The voice is, certainly, reduced occasionally; but beyond effusion I am unable to produce with certainty the conditions which attend diminution. However, I am disposed to believe that the voice may become reduced when, there being a large body of air in the cavity of the pleura, the lungs are retracted and condensed, and when the abnormal aperture is small and permits of only a small acoustic communication between the air in the bronchi and in the pleural cavity.

The voice is generally augmented to a considerable extent in perforation. The man Perry now in the hospital (Oct. 5, 1860) presents the voice on the right and perforated side much stronger than on the left. When the differential stethoscope is applied to both sides of the chest, the voice is heard in that ear only that is connected with the perforated side. The voice of this man is loud, blowing, diffused, hollow, ringing and metallic. Forty ounces of liquid were found after death.

The condition which is predominant, or chiefly operative, in the production of an abnormal augmentation of the thoracic voice, is, I believe, the presence of a large aperture admitting of free communication between the air of the bronchi and the air contained in the pleural cavity. The quantity of air in the pleural cavity may be great without a diminution of voice, provided the communication by the aperture be ample, and the chief bronchi be not compressed.

At the first occurrence of perforation, when the aperture is small and the lung is greatly compressed, it seems probable that a reduction of thoracic voice might take place; and it seems, further, by no means unlikely, that, subsequently, when the aperture becomes more free, and greater acoustic connection subsists between the bronchi and the pleural cavity, this reduction may pass away and be replaced by an actual augmentation. The parts of the thorax where I have found the augmentation most marked have been the posterior or lateral inferior regions.

Of six cases of perforation, of which I have lately taken very careful observations, only one has presented a weak thoracic voice. This patient had splashing sounds, fistulous breathing, and tympanitic percussion. No vocal fremitus or thoracic voice was perceived. The patient left the hospital, reluctant to die there, so that the anatomical conditions were not inspected.

The thoracic cough of perforation is remarkable; it has a loud blowing character, and is heard diffused through the pleural cavity, and acquires a ringing metallic tone.

Vocal fremitus of the chest corresponds with the vocal resonance. When the voice is increased, the vocal fremitus is likewise increased. The augmentation of vibration is very manifest in some cases. In the case of Perry above referred to, the thoracic walls on the affected side vibrate sensibly, and much more than on the healthy side. It is posteriorly and inferiorly that this augmentation of fremitus has been most observed by myself.

The abatement and augmentation of vocal fremitus depend upon the same conditions as affect the vocal resonance. An ample aperture will conduce to fremitus.

The presence of liquid would serve to counteract this at the most dependent parts of the chest.

CHAP. XXXIX.

FOURTH STAGE — *continued.*

Dimensions of the Chest. — Movements of the Chest. — Displacements of healthy Lung and the Heart. — Hydro-pneumothorax. — Table of Seven Cases of Perforation. — Duration. — Vital Capacity. — Cough, &c.

DIMENSIONS.—The size of the perforated side in the fourth stage of phthisis is frequently augmented. A line passed from the sternum to the spine over the affected side is usually longer than one passed over the healthy side. The excess may be as great as an inch, or an inch and a half. This latter is the excess in the case of Perry now in the hospital (Oct. 9, 1860). When much effusion is present in the pleural cavity, which is generally the case when perforation has continued some months, the diseased side will generally be found augmented. In the case of Perry, frequently referred to, the augmentation was due in great measure to effusion. Upon examination after death, forty ounces of straw-coloured sero-purulent liquid were found. The perforation, it may be added here, was unusually large, and found under the second rib in front.

Augmentation would appear to be induced when the aperture is a valvular-like mechanism, admitting of air more freely into, than out of, the pleural cavity. It is easy to see that air is more readily admitted into the pleural cavity than expelled from it. In inspiration the ribs tend to leave the aperture in the pleura, and the perforated lung tends to follow, and is relieved from pressure. This favours the passage of air into the pleura. The air is sucked through the aperture, the fistulous opening is lengthened and lifted from subjacent parts. On the other hand, in expiration, the ribs tend to press either directly or through the air, and compress the aperture upon the parts beneath, virtually contracting it. It is easier to suck to than to blow from. The formation of liquid, too, conduces much to this result, i.e. the increase of the diseased side.

Diminution of size results when the lung has been greatly and permanently compressed, and when the air has a free exit from the pleura or becomes absorbed and is not replaced; in the case of the girl Weare, whose chest was reduced in size, there was no liquid in the pleural cavity, and two large apertures were found in the lung. The lung was very small, but firm. Diminution at the first period may be replaced by augmentation upon the occurrence of effusion, which usually takes place after some weeks.

The dimensions were unaltered in the cases of two females lately under my care.

The shape of the chest in the perforation stage is altered. The lateral regions of the affected side generally assume, for the first time, an abnormally rounded form. The flatness at the upper front is sometimes a little reduced, but it is more generally left unaffected. The alteration in the form of the side is usually very visible after death.

THE MOTION OF THE CHEST IN PERFORATION.—The motions of the thorax in this stage are remarkable for their excess above the natural standard. The inspiratory movements are very rapid, more so than is usually seen in the third stage. The rise and fall of the chest are very frequent, seldom falling below fifty in the minute. It is common to have them as frequent as one hundred in the minute. I have found them as high as one hundred and sixty. On the other hand, in chronic cases,—for such are occasionally seen,—the respiratory sets of movements may not occur more frequently than thirty times in the minute. In the case of Rees, who lived a year and a half after the occurrence of perforation, the inspiratory acts were at first not visibly augmented in number. I cannot say, however, that they were counted.

In this stage the ribs are considerably moved, but it is more in elevation than in outward expansion. The shoulders, too, are generally raised much with the inspiratory act, when the case is acute, and the patient is very ill.

The expansion of the side is usually very much reduced, and can scarcely be said to exist; but this restricted expansion is due to the fact that the full expansion condition has been obtained and is not reduced in expiration. It remains permanent, and therefore no motion is observed. The want of expansion is due, though it sounds paradoxical to say so, to want of contraction. The air is not expelled from the pleura, consequently the ribs cannot fall, which would be necessary to their again rising. It is the same as in copious empyema.

But absence of lateral expansion is by no means universal. In the case of Perry, now in the hospital (Oct. 5, 1860), the lateral expansion is nearly one inch. This expansion is due to the presence of a free communication into and out of the pleura. There is some respiration, but instead of being pulmonary, it is pleural.

In perforation, the lungs of the healthy side and heart are commonly more or less displaced. In cases in which the air has been admitted only in small quantity, or in which the egress is easy, the displacement is very slight. But when the volume of air is large, and the egress is difficult, the displacement may be very considerable. When effusion takes place the displacement is more extensive.

The lung of the healthy side is pushed from the median line, and is embarrassed in its action. It is pressed upon the ribs and interspaces which enclose them. I lately had an opportunity of ascertaining the latter fact. In examining the body of a man who died of perforation, I made an opening into the non-perforation side,—the left, through an interspace, and endeavoured to pour some liquid into the pleural cavity. I found very considerable resistance. On passing a bougie I came in contact with the lung, which sensibly resisted being pushed back. On throwing in only one ounce of liquid, sero-purulent liquid issued from the mouth, the slight pressure on the lung on the left side causing pressure again on the right, sufficient to dislodge the liquid in the pleura, through the abnormal aperture, and thence through the mouth.

The heart in many cases is displaced by the pressure of the air, itself unduly pressed upon by the ribs. It may be thought that it is contrary to physical laws for the heart to be displaced, as that organ has air to press upon it on both sides. An equilibrium of pressure, however, does not hold. It is to be borne in mind that the conditions differ much on the two sides. It is true air presses on both sides, but the air on the perforated side presses with a force greatly more than that holding on the other,—the simple pressure of the atmosphere. The air on the perforated side when enclosed and denied egress is itself pressed upon by the elastic walls of the chest, and by the expiratory muscles, and it again presses upon all around it with a corresponding force.

When perforation takes place on the right side, the heart tends to be displaced to the left, and *vice versâ*. It is when perforation exists on the left side that the heart appears to be most displaced: it is felt to be at the right of the sternum.

In the case of Farrell, whose body was examined lately, I found the heart greatly displaced. It lay under the sternum, and rather more to the right side. The apex, instead of being directed obliquely to the left, was maintained in the median line of the body. The left ventricle was compressed and flattened, and the heart was of more uniform breadth from base to apex than natural. Only six ounces of liquid were found in the pleural cavity.

The sounds of the heart, when displacement to the right takes place, are heard loudest on the right side. In Farrell's case, the impulse was felt to the right of the sternum.

Displacement of the heart and healthy lungs, as well as great compression of the diseased lung, may be brought about in this manner. A long continued cough takes place; to this succeeds a strong gasping inspiration, the aperture is much dilated, a great volume of air passes into the pleura, which only imperfectly escapes during expiration. This air is subjected to great pressure, and it again presses upon all around it.

THE POSITION OF THE CHEST WHEN THE PATIENT IS IN BED.—The trunk is raised generally about an angle of 45°. When the patient rests upon his side, it is generally upon the healthy one. When much effusion is present, he lies upon the diseased side. I have known cases in which the patient showed no preference for one side over the other. He will often sit upright in bed, bending his shoulders greatly forward, for an hour or two, or until exhausted with the necessary effort.

Some patients will lie exclusively on the diseased side for a length of time. All at once they then manifest a preference for the diseased side. Latterly, the patient Perry lay and slept exclusively upon the diseased side; and a day or two before her death Farrell turned on the diseased side and died upon it. This change occurs when liquid forms. The patient now seeks the posture of empyema.

EXTERNAL SOUNDS.—I deem it right to mention a curious phenomenon which I have noted in connection with the auscultation of the perforated side. Loud, sonorous, external noises have been heard by me, when using the stethoscope, to come with much resonance from the air-filled side. The external vibrations have affected the side and caused it to consonate.

HYDRO-PNEUMOTHORAX.—The addition of liquid to air in the pleura has been spoken of already. This compound condition is called hydro-pneumothorax. Effusion may or may not occur in the perforation stage. It is true that the effusion of liquid tends to take place after perforation.

Hydro-pneumothorax is found in nearly all cases of perforation of above some weeks' duration. It is signalized by dulness on percussion at the very lowest part of the thorax, and when that is the abdominal end of the cavity, directed more to the abdomen than to the thorax where the air is confined, the air somewhat counteracting the dulling tendency of liquid. Splashing is to be evoked. Metallic tinkle is heard, but not more than in cases of simple perforation. The dimensions of the side are increased. The chest is rounder, and the intercostal spaces are more than usually prominent. Displacements of the heart and lungs of the opposite side are common and to a more marked extent than in simple pneumothorax. Ægophony, the characteristic of pure empyema, I have never heard in hydro-pneumothorax, the result of perforation in phthisis. In cases of hydro-pneumothorax, fœtid pus or sero-purulent fluid may be passed through the fistulous opening and expectorated.

I append a table of seven cases of perforation seen by me lately. Six were my patients. One was Dr. Cotton's. From this table, as far as it goes, it appears that both sexes are equal sufferers, and that both sides are equally liable to perforation :—

Sex.	Age.	Affected side.	Physical Signs, &c.	Autopsy.
F.	25	L.	Amphoric respiration sounds. Percussion tympanitic. Crepitation, left base near spine	
M.	20	R.	Feeble amphoric respiration sounds. Fistulous sounds. Metallic tinkle. Splashing. No voice or fremitus. Right side enlarged	
M.	20	R.	Amphoric blowing sounds. Metallic tinkle. Tympanitic percussion . . .	
F.	15	L.	Tympanitic percussion. Metallic tinkle. Left side smaller.	Two apertures. Lymph on pleura. No effusion.
M.	20	R.	One metallic tinkle to each inspiration. Crepitation right apex. Sighing amphoric respiration. Most voice on right. Decubitus on right. Right side larger .	40 oz. of Liquid.
F.	21	L.	Tympanitic percussion. Blowing inspiration and expiration sounds. Single metallic tinkle. Amphoric voice. Both sides alike. Lies on right . . .	
F.	34	L.	Blowing amphoric respiration. Tinkles numerous. Tympanitic percussion. Lay on right till a few days before death.	Heart flattened, displaced. Great orifice. 6 oz. pus.

Duration.—The duration of the signs of perforation is short. The average is about one month or six weeks. But like the signs of most diseased actions to which man is subject, those of perforation vary much in duration. When we consider the varying conditions under which perforation takes place, the various events which arise, and the varying powers of the patients, we need not wonder that the average is not nearly reached in some cases, and that it is greatly exceeded in others.

1. My patient Farrell died about two weeks after the first discovery of perforation signs.
2. D. died one month after detection.
3. W. died a month after detection.
4. P. died six weeks after.
5. C. died a few days after.
6. — died six weeks after.
7. R. died eighteen months after.
8. A. died two months after.

But it is to be observed, that the period between detection and death is an imperfect measure of duration. The signs probably existed a considerable time before their discovery.

VITAL CAPACITY.—The vital capacity must be very low in the stage of perforation. One lung will hold scarcely any air; but we must remember, however, that though the lung holds little or nothing, the pleural cavity both receives and discharges air. Pleural respiration, so to speak, still goes on, though this is truly in small amount.

I am not aware that physicians have actually ascertained by experiment the lung capacity of perforation patients. For my own part, I have scrupled to test my patients in this way. Their exhaustion and distress make it a point of duty in general to omit this inquiry.

The cough of perforation is peculiar. It is extremely short, consisting, for the most part, of one or two short quick forcible expirations. In some cases this is repeated almost incessantly, the patient having scarcely time to utter a word or two without being interrupted. It closely resembles the cough of pleurisy. But in addition to this peculiar cough the loud, sonorous, moist, and deep and protracted cough of the third stage is experienced from time to time.

The sputum is perhaps more scanty than during the third stage. I have seen it reduced to a small amount of thin, frothy, gummy-looking liquid. I have never seen blood in the sputum.

The voice is with difficulty formed in bad cases. It is a low voice, and feebly and painfully uttered.

The mouth and pharynx, &c., are much the same as in the third stage. I have seen the tongue as clean as in health.

PART II.

CHAP. XL.

PRACTICAL DIRECTIONS.

Necessity of early Exploration.—Thorough Examination.—The Room.—Temperature.—Light.—Silence.—Posture.—Inspection.

In the preceding part of this work the results of the examination of the phthisical patient have been fully given, but it remains for me to say how these results are best obtained, so that, by the employment of the most approved methods, the patient's disease may be most clearly made out, and the instruction of the student be consulted.

Fulness of examination.—When a patient comes before the physician, under circumstances rendering it reasonably probable that his symptoms are due to the presence of pulmonary consumption, however *early*, whether these circumstances be the actual symptoms of thoracic disease, whether it be that the patient is himself suspicious and anxious, whether relatives desire an opinion, whether an insurance company seek information, or whether a brother practitioner desires a second opinion, in respect of this disease, it is most important and it is imperative that a sufficient examination should be made, and that at as early a period as possible.

The very fact that a patient seeks advice on his own account, or that he is sent to us whether by professional or non-professional parties, should constitute in our minds a warrant for full examination. This should hold in even apparently trivial cases, for it often happens that apparently very trivial cases are really very serious ones. How often has a patient been deprived of suitable medical treatment; how often and how long has he been exposed to injurious agencies; how often has a patient entered into long engagements of a ruinous character, because he was never to see the end of them; how often has he taken social steps injurious to himself and others,—simply because this rule has been disregarded? Again, how often has the kind, and even the skilful and deserving, medical man been the almost innocent sufferer in his reputation by his too great confidence that no physical examination was required?—and again, how often has the consulting physician and "the second opinion" obtained great, and perhaps not undeserved, credit and reputation by instituting that inquiry which the first, and perhaps equally well-informed physician had, from too great ease of mind, from dilatoriness, or from modesty, neglected to carry out, but which he was perfectly competent to institute.

Take, again, the case of the patient *in extremis*, even in *articulo mortis;* we are bound to make a sufficient examination. A few minutes well employed,—no pain, no inconvenience to the patient being involved,—we are enabled to pronounce positively on the nature of the disease, to specify its stage, its seat, and its chief local characters. This is a satisfaction of great price to relatives and to the physician; it may be, too, to the patient himself, who is yet called upon to make some important and immediate decision.

Yet again, let us imagine a case, by no means very rare, of a patient greatly reduced in flesh, very ill, and in daily expectation of death. Such a patient has many of the symptoms which consumption produces, but which, in this particular case depend upon other conditions of a comparatively unimportant nature. To examine such a patient, to discover only healthy respiration sounds, and to give a corresponding report, is surely a service of immense value.

The examination of a patient suspected of phthisis should be undertaken at an early period. If possible, it should be made at the first interview. If, however, time and circumstances will not permit of a tolerably full examination, it is better not to undertake it at all at the time, but to postpone it to another opportunity, giving in the mean time an opinion on the symptoms only, reserving a decided statement on the nature of the disease, and prescribing for urgent symptoms and offering some safe rules for regimen. It will sometimes happen that the patient is too ill at the first interview to submit to a full and protracted examination. In this case, the discovery of some of the more important signs should be attempted, such as gurgling, liquid crepitation, and very dull local or general tympanitic percussion sound. Such conditions as these signs reveal will afford prima facie grounds for an opinion and indications for treatment. In the case of very nervous and very timid persons, it is sometimes necessary to postpone full examination. The sight of the stethoscope, the idea that an examination is about to be made, causes so much distress and agitation to some patients, that it is prudent and justifiable to postpone the inquiry. Children, too, frequently evince a horror of a strange doctor, shriek, and struggle against the attentions of their new visitor. In such cases it is better, in a good-natured manner, to retire, seem to consult the little patient's feelings, improve acquaintance with them, and, when they have lost all apprehensions, which, like little birds, they soon do, then to institute a thorough inquiry. When urgent inflammatory symptoms are present, it may be necessary at the first interview, even with refractory children, to permit of no delay. The laying aside of the stethoscope, and employing the naked ear in an easy familiar manner, will facilitate the examination as far as relates to auscultation.

The examination should be complete. In deciding so important a question as the presence or absence of pulmonary consumption, every reasonable endeavour should be made to render our knowedge of the physical condition of the chest, &c., complete. To this end no reasonable labour should be spared. The patient, too, who is to be the chief gainer by the scrutiny, must aid, and make whatever sacrifice of comfort and feeling that is reasonably demanded. If, at the first interview, circumstances prevent the examination being complete, which should be a rare case, an early opportunity should be taken to make it such. No practitioner should rest satisfied without the assurance, and it should be a well-grounded one, that his examination, if really cursory, has been as complete as circumstances reasonably admit. No trivial or temporary circumstances should serve, even in his own mind, to warrant an incomplete inquiry for any length of time; certainly they will not defend him against blame on the part of the patient, the friends, and his more active and inquiring professional brethren. I have known of superficial inquiries, and some of them have been pernicious to the patient, annoying to his friends, and very injurious to the reputation and comfort of the physician.

The cursory, the imperfect, and slovenly examination is to be eschewed by every medical man who cares for his patient or for his own success. The examination which answers to this description, though, perhaps, common formerly, is now nearly extinct; yet as it does occur from time to time, even now, and as we are all prone to relapse into error and culpable ease, it seems not to be supererogatory to notice it here. This examination consists of hurriedly percussing the chest, through the clothes; travelling from one part to another before the mind has settled the character of the sound emitted from the first part; the placing the stethoscope upon the upper front of the chest not made nude, and listening, even though with some attention. To practise such an examination, when the practitioner is competent to do better things, is culpable. To purchase ease, or a few minutes, by such an unsatisfactory proceeding is most improvident. For such results the patient often pays an enormous price, the price of his health, his prospects, nay, life itself.

The examination of the patient cannot be efficiently performed unless a sense of the serious character of the inquiry prevail. To carry levity and jocoseness into such investigations is incompatible with the full and clear results that should be obtained. The joke, the repartee, and the laugh, are all greatly opposed to an efficient and sober examination. Though the patient may not be aware of it, we are really ascertaining whether there be present conditions which affect most materially the value and the duration of his life. While the physician is earnest, and this need not make him gloomy, or even otherwise than cheerful, he should deprecate every approach to levity on the part of the patient or of those friends who are with him. No rash or jocular assurance should come from the physician, ere his examination is well begun, that "there is no need for examining," that "the lungs are quite healthy," or that he would "insure his life to-morrow." I have seen the laughing expression of the practitioner, and the comforting assurance of one moment, exchanged the next for a very different look and a very different style of remark. The comforting assurance of fair percussion has been quickly followed by the gloomy intimations of cavernous gurgling. The physician is frequently disturbed by the over-confident patient, who assures him that "there is nothing the matter," that "it is only a cough," and that he does not require a physician. All this should be prevented, and the physician permitted in peace to arrive at a knowledge of the case, the nature of which cannot be altered in the very least by the comfortable (for the time) convictions of the patient. It sometimes requires firmness to meet this evil, and it may be necessary to speak seriously to the patient upon the subject. He will be the last, if his case be ill diagnosticated, to excuse the physician, who has permitted himself to be led into error by an ill-timed interference, though it [illegible]eeded from himself.

The room in whi[illegible]t is to be examined will depend much, of course, upon his being out of bed and able to move about, or his being confined to his couch. In the latter case, no selection can be made, and we must simply see that the room is made as available as possible for the purpose. When, however, the patient is able to move about, the room selected for the purpose requires some attention. Is is essential that the temperature be above 60°, and it is of the greatest importance that it should possess a good light. Its suitableness for the purpose is increased, I believe, by its having no great amount of soft furniture, such as curtains and carpets, which destroy sound.

The temperature is of great importance. A cold atmosphere will greatly interfere with the examination. In general the inquiry will require ten minutes, and for a man with his chest nude to stand that time in an atmosphere the temperature of which is materially under 60°, is to bring on tremblings, which tend to impair accuracy of observation, particularly in the early periods of the first stage of pulmonary consumption. Besides, the symptoms of the patient may be aggravated by exposure to cold. The timidity of patients under examination aids materially the tendency of cold to produce shiverings. This is not confined to women and children. I have seen strong men in rigors from this cause. I remember seeing a stalwart Life Guardsman in strong rigors from exposure to a temperature, for a few minutes, not much below 60°. If the patient be very sensitive to cold, which is by no means rare, he may be placed near the fire, if there be one, and no unnecessary time should be spent. Inquiries which may be made as well when the patient is dressed, should be avoided or postponed. I have occasionally seen a man kept with his chest nude, answering inquiries for a considerable time which could have been done as well after the examination, i.e. after he had dressed.

The light is of great importance. Good daylight is better than an artificial light. In the examination of the form and the movements of the chest, &c., a good light is indispensable. I have known good physicians overlook abnormal conditions both of form and motion from insufficiency of light. The light which answers best, in my experience, is a front one, partly on a level with, or a little above the patient. A single light, i. e. from one window, coming direct to the patient, is better than a double one. Side lights are to be avoided; they illuminate one side more than another, and deviations, slight in extent, in relation to movements and form, may thereby be overlooked. Lights from above, as sky-lights, do not answer so well as a single front light. The patient should, if possible, be placed opposite the middle of the single front light. When we examine by artificial light, it should be a strong one, and placed or held in front of the patient, while the physician examines on either side, in strictly corresponding positions.

The doors and windows should be closed during an examination. The chief advantage thus allowed is the prevention of the entrance of extraneous sounds when we are auscultating. Some advantage is also procured by the confinement of percussion sounds. By the closure of the doors and windows, too, draughts of cold air are avoided. The patient and the physician are also less liable to be disturbed.

Silence is of the greatest consequence. For this reason, the fewer persons who are present the better. When, however, several are present, it is necessary to enjoin silence, particularly during percussion and auscultation. It may seem unnecessary to speak of this, but I have found in practice that friends of patients, even intelligent persons, have been disposed to talk, even on irrelevant matters, as if they had been sitting in their family parlour. They may be, when thus transgressing, politely informed that silence is necessary. It is not the silence of the tongue only that we have to desire. Fidgety persons will be found, who are continually moving about, and if dressed in silks, and in the amplitudes of crinoline, these inflated peripatetics will greatly interfere with us, and tend to cause erroneous conclusions that sounds coming from themselves originate in the chest of the patient. Such persons must receive a caution. We can scarcely overrate the importance of silence. I have myself experienced much inconvenience by the simple cracking of coal fires, and the rushing noise of gas, when put strongly on. Persons who cough should be requested to leave; crying children are not for a moment to be tolerated. At the hospital, I am often induced, in order to avoid serious acoustic errors, to request coughing patients, when they are able, to leave the ward in which I am making a careful examination. The evil from this interruption at the hospital is sometimes very serious, and has occasionally suggested to my mind that for patients out of bed, a room might be advantageously fitted up, in which to examine them in succession.

The patient is to be assured and comforted. He is to be kindly and considerately treated. It is well to inform him that he has not been specially selected for examination, because his case is specially serious, and that all patients, even with only apparently trivial symptoms, are similarly dealt with. This assurance will frequently succeed in giving courage to the patient, and in tranquillizing his respiration. A few kind words adapted to the patient's case will often be necessary, and produce an immediately soothing influence. Observations respecting the real or suspected habits of the patients, abrupt questions as to the cause of death of a father, or a mother, or of a child, are calculated to throw the patient into agitation and into uncontrollable fits of crying, rendering all attempts at auscultation perfectly nugatory.

For the performance of the greater part of the physical examination, the standing position of the patient is the most suitable: the physician standing also. In this attitude of the patient, the physician can inspect the various aspects of the chest by walking round it. Or the chest of the patient is brought into view at its different parts in succession, by simply turning the patient round. In this posture the form and movements of the whole thorax are seen; the chest may be felt, percussed, auscultated and measured with great advantage. The patient is enabled to move his arms freely about, to bend forward, to lean to a side, and to place his hands over his head. But in order to adopt this position during the examination, some considerable strength on the patient's part is required. Many persons who are able to come to the house of the physician, are unable to bear this fatigue, and it is necessary to exchange it for the sitting or recumbent posture. I have seen patients not greatly wasted, faint under the fatigue and excitement of the erect examination. But when the patient is unable to have the whole examination performed in the standing attitude, part, viz. the inspection may perhaps be so carried out.

The sitting posture I have found less convenient for myself, both in respect of ease, which is of great consequence in the examination, and also for correctness of observation. But it is not greatly inferior to the erect posture, while to many patients,—those who are weak and nervous, it is more tolerable, and is less frequently attended with trembling and disposition to fainting than the erect posture.

The recumbent posture in bed or upon a couch is, in some cases, the only one which is admissible on account of the exhaustion and suffering of the patient. When feverish, when weak, as the patient often is in the second, third, and almost always in the fourth stage of the disease, the recumbent posture is the only one in which the greater part of our examination can be made. It is true that in many of the cases indicated, the patient may be enabled to sit up in bed for a minute or two while the dorsal aspect of the thorax is expeditiously examined. Even the exhausted patient may be made to lie alternately on both sides, and he may be induced sometimes to lie prone for a moment or two.

When the patient is suffering from acute intercurrent inflammation, the examination should be carried on in bed, and the patient should make little or no effort.

In the case of hæmoptysis, special precautions are necessary. Percussion should be gentle, and the patient should not be directed to speak much or to cough. If the patient be induced to cough, hæmoptysis may be increased or made to return with violence when it has already abated.

When the patient experiences pain on the surface of the chest, percussion often causes severe and acute suffering: this therefore should be very gentle. The stethoscope sometimes causes so much pain that the patient winces much, and thus interferes with auscultation. Under such circumstances, the practitioner will press very lightly with his head. In such cases, I have found the double and the differential stethoscope very useful, and readily tolerated by the patient. The water pad or hydrophone applied under them, will deprive the examination of every vestige of distress. The naked ear, too, in such cases, is better than the wooden stethoscope. Children, when very young, may be examined in the arms of the mother or of female friends. They frequently refuse to be otherwise reconciled to our attentions. When examining the posterior aspect of the thorax, the young patient may be placed over the mother's shoulder, and have its attention diverted.

It is not essential in every examination of a patient for the first time that all the usual tests should be employed. When the chest is very tender, slight percussion only can be employed; when the patient is in bed and very ill, mensuration may be postponed or altogether omitted. Auscultation, however, cannot be dispensed with under any circumstances. But the vital capacity should on no account be taken the first examination, unless the patient's strength and composure are very considerable. No one would think of this test in cases of exhaustion or timidity. Nor is it proper in very serious cases to make observations with stethometers and other useful, but now inappropriate, instruments, the results of which would be beneficial rather to science generally, and the physician, rather to than the patient. In all examinations of the phthisical, or of those suspected of phthisis, it is of extreme importance that we should inquire most into those points which are of greatest consequence. The grand auscultatory signs are of more importance than refinements in mensuration and shape, and when circumstances permit of only a few minutes' examination, this should not be forgotten. To apply stethometers, goniometers and laryngoscopes in a case of perforation of recent occurrence, and attended with agony, is not only injudicious, but argues the absence of common sense, the highest attribute in the character of a physician. Attempts at unnecessarily copious information do not always escape the critical notice of the patient, or of his non-professional friends standing at the bed-side.

The patient, standing or sitting before the physician,—for the occupancy of the bed we must regard as an exceptional case,—the chest is to be totally denuded. The patient, after having been told to uncover his chest, after having taken off his coat and waistcoat, will often ask whether he is to take off his shirt? and having had his directions again plainly given, and having taken off his shirt, will repeat the same question in reference to his flannel waistcoat. It is not without a considerable trial of patience on the part of the physician, in some cases, that the patient will comply with the very plainest directions to undress his chest; for intelligence and disease are not inseparable, as I have often found in the out-room of the Hospital for Consumption. However, temper must be maintained.

When inspecting a chest at the hospital, I place myself before it, and move from side to side. I endeavour to look also from above. I examine and note the shape, its great characters, such as its breadth and depth. The peculiarities of the natural conformation being noted, I regard those that have evidently been acquired. The apparently mere osseous deviations in shape are noted and separated from those that are produced by internal disease. The mere professional or trade curve of the spine, with its elevated shoulder on one side, and its depressed shoulder on the other, arrests my attention only for a moment. I look to see whether the two subclavicular regions are normally prominent, and that they are symmetrical. If one be flattened compared with the other, I look to the spine and observe whether it is curved, and I look to other parts of the chest to see whether they are normal. If the spine be curved, and other parts of the chest be abnormal in shape, as, for instance, one shoulder be high and the other be low, and the sternum be protuberant or oblique in its direction, for the moment I attach little importance to it. But if the spine be free from curvature, and there be an obvious want of motion in the part during respiration, I regard the flattening as a presumptive sign of pulmonary disease, and that, most probably, of a tubercular character.

A comparatively small lateral region occurring, with flattening at the subclavicular region, for the most part indicates the consolidation of phthisis and of phthisical pneumonia.

In inspecting the chest, I note, as a most significant sign, the pulsation, the waving pulsation, of the heart at the first and second intercostal spaces, continuing even during expiration, often increased at this time. This waving, it may be stated, is more common at the second space than at the first. If in a case of a patient wasted with chronic disease, cough, and sputum, and troubled with shortness of breath, and presenting some flattening of the subclavicular region, it be present, I have generally, almost always, found that it is a result of phthisis in the third stage. On witnessing this waving, superficial, fluctuating kind of motion, I have frequently been enabled to pronounce correctly upon the true condition of the patient. It has enabled me to say, "there is a cavity on this side;" and I have scarcely ever been deceived, or have received correction from the application of the stethoscope or of other means of exploration.

In employing the test of ocular inspection, we must regard the muscles. These are often found in a strained, projecting position, and of a somewhat cord-like, or even stringy character. When the chest is percussed, I have seen the muscles involuntarily contract. This, of course, is of no moment. The veins of the chest and neck must be inspected. Numerous blue and dilated veins coursing over the chest have, for the most part, associated with them pulmonary or cardiac disease.

Dilated veins in the neck indicate intra-thoracic disease. When we observe dilatation confined to one external jugular vein, we shall generally find phthisis, in its second or third stage, in the lung of the corresponding side. There are cases, however, in which this partial dilatation is due to cardiac disease and mediastinal tumours, and to aneurism within the thorax.

We note the various aberrations from the normal movements of the thorax, whether they relate to the external muscles, the elevation of the ribs, the descent of the ribs and sternum, and even the rise and fall of the abdomen in the acts of inspiration and of expiration.

CHAP. XLI.

Percussion.—Simple Percussion.—Percussion Hammers.—Pleximeters.—Dr. Aldis's Echometer.—Dr. Sibson's Pleximeter.

PERCUSSION.—After inspection of the form, size, and movements of the thorax, the next step is to percuss the chest. To effect this object fully, I invariably, in the case of females, remove all head-dresses that come down below the ear, and I place ringlets out of my way. If we percuss the patient in bed, we should remember that such soft material as a feather bed dulls sound. Percussion informs us, in a general manner, of the proportion of air and solid parts, and of the facilities for vibration which hold in respect of the parts percussed, and of the parts to which the percussion blow reaches. A material excess of solid parts, a material diminution of air, a material excess of air and a loss of freedom for vibration, are revealed by the act or art of percussion. The seat, the extent of certain percussion sounds, quoad space and amount, further suggest the nature of the disease producing the observed results; but auscultation, and the history and the condition of the patient as to symptoms, are necessary to denote with exactitude the precise and certain nature of the morbid conditions.

When the form of the chest is natural, as is often the case in the first stage of phthisis, and nothing during inspiration is discovered to throw suspicion upon any particular part of the chest, it is best in percussing to proceed from the apex downwards to the base in front, taking in succession double observations, i.e. observations on both sides of the chest at strictly corresponding parts. Thus we percuss the space lying between the clavicle and the scapula above, on one side, and then percuss the same region on the other. By comparing sounds thus obtained from the two sides, a difference in resonance or in duration will frequently be appreciated, when in their naked, absolute characters they would pass as presenting nothing abnormal. After having percussed the whole front of the chest, the lateral regions are to be examined; the arms, which had previously been kept in a hanging, easy posture, are now to be elevated over the head, with the hands clasped, and resting upon it. The double observation is again to be made.

Here, in the first stage even, in some cases, a difference of resonance will be obtained, for congestion, and even some degree of hepatization are not uncommon. For the most part, marked abnormal percussion sounds are obtained posteriorly, only low down below the angle of the scapula. Beneath this point, in a large proportion of first stage cases, shortness of duration, and some degree of dulness are procurable. In almost all cases of the second and third stages, percussion at the base is sensibly modified. In the fourth stage, percussion resonance is tympanitic, even though a considerable amount of effusion have taken place.

The percussion of patients in the first stage of phthisis requires more care and circumspection than in the later stages.

When phthisis has greatly advanced, and depression of the upper and anterior part of the chest has taken place, or when the heart is seen or felt beating at the second interspace, I at once percuss these parts, and generally obtain an amount of information almost decisive of the question of excavation. In such cases a dull sound is usually obtained, and the stethoscope immediately after reveals some of the signs proper to cavities already noticed. The great features in the case that relate to disease and life prospects are fully and momentarily made out. Further examination may now be carried out; but the grand facts have been already obtained, and if the patient be exhausted, the further exploration need not be very minute.

In order to know that the percussion sounds obtained from the chest suspected of phthisis are healthy or unhealthy, it is necessary, and of the very first importance, that we should know the percussion sounds appertaining to the chest known to be healthy. I shall not in this place describe the natural or normal healthy sounds: these are to be learned only by practising percussion on healthy persons. With a view to the acquisition of knowledge highly important, the future percussor should examine the chests of persons at all periods of life, childhood, puberty, early middle and advanced adolescence. The chest of the fœtus and the newly-born infant should not be omitted. The percussion in respect of these periods of life, I would only now say, varies very considerably. In the fœtus, percussion is short-dullish. In the infant, child and youth, it is resonant. In the young adult, it is resonant and bold. In the old adult, it acquires a degree of shortness from the rigidity of the bones. In some, and these are not few, the rigidity of the bones is counteracted and exceeded by the influence of emphysema, and we have then a more than usually resonant percussion sound.

In percussing, various methods are employed: one physician preferring one method, another preferring a different one. Without arrogating to myself superior judgment, I may be permitted to describe my own method first. My method is the mediate one. I make use of the hammer and the pleximeter that nature has kindly provided me,—those which cost nothing, that require no box or case, and that, moreover, cannot be left behind. In a word, I employ the fore and middle finger of the right hand as a hammer, and the fore finger of the left hand as a pleximeter. The first strike the blow, the other receives it. I find the employment of these parts only amply sufficient in most cases. When a very strong blow is to be made use of, the ring finger of the right hand is added to the others.

The finger employed as a pleximeter or blow receiver is laid gently and with a little pressure over the part to be percussed, with the back or hard or bone part looking outward. No air is allowed between the finger or fingers and the chest, otherwise a pseudo cracked-pot or clink sound may be obtained by its expulsion. The finger is laid across a rib, or which is better, in an intercostal space. I find in many cases that the finger fits best applied to the interspace; and I believe that a given blow produces a fuller sound when the finger is placed there than when placed upon the rib. When the intercostal space is depressed either from plastic adhesions or from wasting, it is best to place the finger *in* it and not across it. Air expulsion sounds are thus avoided.

The finger or fingers employed to give the blow should fall neatly and decidedly upon the middle of the back of the pleximeter finger. A moderate blow is perfectly sufficient in ordinary cases. The hammer fingers need not be raised above the pleximeter finger more than one or two or three inches, before they are made to descend. By confining the separation to this extent, the danger of a side blow being struck, or of missing the finger altogether, is avoided. The fingers should fall at right angles. The arm need scarcely be moved. The hand is moved simply upon the arm. By attending to this and keeping the finger points at the same level, a cleanness of blow, so to speak, is secured, difficult to obtain by great movements of the arm and shoulders.

We should avoid heavy, clumsy blows. I have seen the arm and the shoulder employed in percussion, and the fingers separated from the chest about a foot. Such percussion is inexact, painful to the patient, and conveys an impression of awkwardness and unskilfulness that had better be avoided.

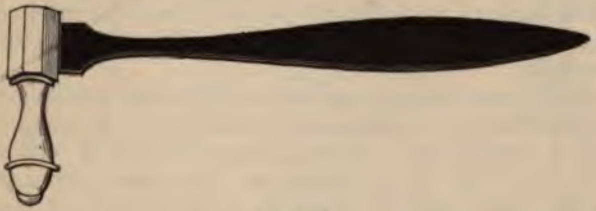
Considerable force is occasionally justified when moderate percussion fails to detect a departure from the healthy sound. In deep-seated tubercle rather forcible percussion will sometimes elicit a degree of dulness when this cannot be obtained by light tapping. A strong blow in cases of empyema, and in perforation too, seems to effect a contrast which is not so well secured by gentle percussion. A strong blow is also justifiable if we desire that the character of the percussion sound should be heard by several bystanders.

When the blow is struck upon the finger, this part should be immediately dealt with, so as to avoid constraining pressure, for the production of sound, as I have already often said, is greatly hindered by pressure.

The mode in which the finger acts which serves to receive the blow has been little noticed. The employment of this part is very necessary, for if we attempt to percuss without it or without a pleximeter, we fail much in our efforts. Even if we percuss the soft part of the finger instead of the hard part, the result is greatly inferior. When the naked chest is struck directly, the fleshy parts act so as to prevent that amount of forcible collision sufficient to set the contained parts of the chest into sonorous vibrations. When the hard part of the finger is struck, forcible collision is produced, and this is transmitted to the parts beneath, now rendered more solid by the pressure of the finger. Percussion of the clavicle, as it is little covered with soft parts, does not require a finger to be placed upon it, for the collision between it and the end of the finger is sufficient to throw the parts beneath into sonorous vibrations.

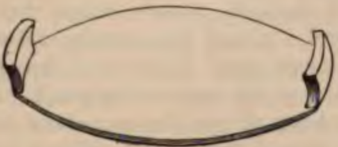
The cracked-pot sound is best elicited by a smart, clean, strong blow. We should aim well, for faulty efforts do not succeed, and by partially emptying the cavity of air, may frustrate other blows, however well delivered.

Hammers have been recommended by various physicians for the purpose of giving the blow. It has been said that greater uniformity of force is thus secured. But I myself have not found the employment of a hammer of much use. In ordinary percussion I infinitely prefer my naked hand and fingers, the movements of which I can regulate fully as well as those of a hammer. Besides, I obtain the benefit of the perception of chest resistance. The hammer strikes a pleximeter, for the most part a disc of ivory or indiarubber. The hammer is usually formed of steel, and is about four inches in length. The part which comes in contact with the pleximeter is tipped with a point of indiarubber. There are some occasions on which such an instrument may be useful,—when a heavy blow is required, which, however, must be rare; when it is necessary to elicit loud sounds, as in teaching students; or when the arms and hand of the percussor are feeble. Dr. Theophilus Thompson, I believe, had a very healthy view of the value of the hammer. When that physician lost much of the muscular power of the hand and arm, he proposed to bring this instrument to his aid in percussion, as he himself informed me. I fear his death soon after prevented him or his patients benefiting by his proposal. The hammer is much employed upon the continent. Dr. Hughes Bennett employs it, and probably his success in procuring the cracked-pot sound is connected with this fact.



Hammer.

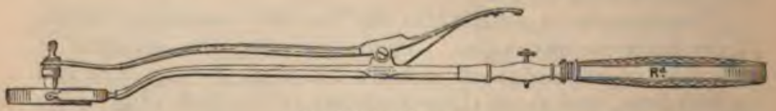
Pleximeters, or substitutes for the blow-receiving finger, have been recommended. That of Piorry, the inventor of this aid, is made of ivory, being a thin oval disc, an inch and a half long, and about three quarters of an inch wide at its widest part.



Piorry's Pleximeter.

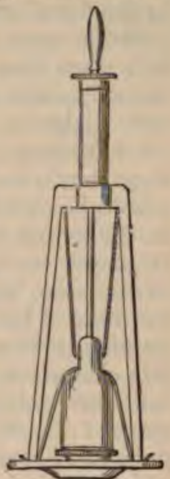
Some pleximeters have been formed of indiarubber. I have employed these instruments, but I have abandoned them in ordinary percussion. I found that they produced sounds of themselves rather than of the chest. They fitted ill in wasted patients. I have found air confined under them, and again this has been expelled with a noise often clinking during percussion. They are greatly inferior to the finger in respect of the sense of resistance, and of nice ready management. When the hammer is employed, the pleximeter is essential. The pleximeter is to be placed in or over an intercostal space, or upon a flat surface, and fitted well with gentle pressure upon the body, and held by the thumb and forefinger of the left hand. It may be employed together with a hammer or with the fingers. The blow is struck at the middle.

An instrument combining both a pleximeter and a hammer was contrived by Dr. Aldis some years ago. It consists of a hammer moving on a fulcrum, and of a disc of cork which receives the blow of the hammer. The cork disc is placed upon the chest, and the hammer is raised by the finger to the required height. The higher the hammer is raised, the more force is obtained. The hammer falls by the operation of a spring. Great uniformity of blow is obtained by this instrument. This ingenious contrivance has obtained the name of echometer. I have made use of the original instrument, kindly lent to me by its author. While the sound obtained by the echometer varies sensibly with the resonant quality of the chest, I must confess that the sound of the instrument itself has perplexed me, and I have missed that fine adjustment and appreciation of the blow, and of the resistance, and also the power of immediately suspending pressure which I enjoy in simply using the unaided fingers. Besides, the force cannot be greatly varied as when the fingers are employed, and I have, in using the echometer, soon found my hand to become fatigued. It may, however, be useful in teaching percussion to a class.



Dr. Aldis's Echometer.

Dr. Sibson's pleximeter.— Dr. Sibson has more recently contrived an instrument of a similar character. Dr. Sibson's pleximeter consists of a plate of ivory which receives the blow, and of a brass hammer or weight working in a metal frame. The weight or hammer is raised by the fingers; these being removed, the weight or hammer falls upon the ivory plate by the elasticity of an indiarubber band connecting the weight or hammer with the ivory plate. The hammer works perpendicularly to the plate. I have carefully experimented with this instrument, and I must admit it to be a superior and valuable instrument. The working of this instrument is easy, the hand does not become tired, it is little formidable in aspect to the patient, it is not expensive, and the force can be nicely varied. The different degrees of resonance are well marked by this interesting and pretty instrument. If we percuss the crown of a hat, a different note is obtained by any move of one quarter of an inch from the centre towards the edge. The degrees of resonance are also well made out upon the phthisical chest. Perhaps for a physician not yet able to make uniform strokes with his fingers, this instrument would be useful. But I must confess, that in infinite variation of force, and in rapidity and nicety of percussion, the fingers of the practised percussor are greatly superior.


Dr. Sibson's Pleximeter.

CHAP. XLII.

INSTRUMENTS.

Auscultation.—Immediate.—Mediate.—Laennec's Stethoscope.—Solid and hollow Stethoscopes.—Materials for Stethoscopes.—Construction.—Application.—Extraneous Sounds.

Auscultation.— After having obtained every reasonable information from the practice of percussion, the patient suspected of pulmonary consumption is now to be submitted to the test of auscultation. In every stage of the disease, this test reveals facts of the highest importance; it is the most valuable one which we possess, but it is in the first stage of the disease that auscultation exceeds most in importance all other modes of investigation. We obtain much light, direction and suggestion, from the coarse, deficient inspiratory sound, and the coarse prolonged sound of expiration in the first stage. The moist crackling of the second stage is most significant. The cavernous blowing in and out, the cavernous voice, and the cavernous gurgling, speak with force of most serious disruption in the third stage. The amphoric blowing, the amphoric diffused vault-like voice, and the metallic tinkle convey truths to the mind at once of the most unquestionable import, and of the saddest significance in the fourth stage of the disease.

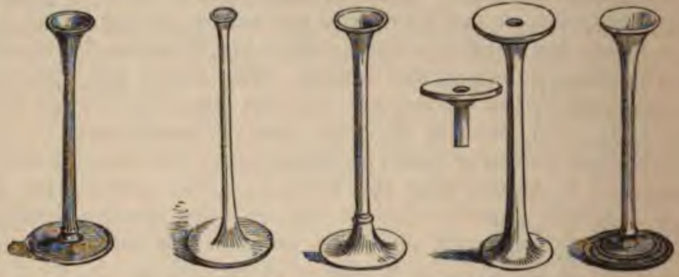
While auscultation is of more relative importance in the first stage than in the second, it is also more delicate, and demands more care and circumspection. Its results, too, are more liable to be confounded with those of auscultation in other diseases. For these reasons auscultation in the first stage should be undertaken with great care, and all diligence should be exercised to attain the utmost possible information. In the second stage, the discovery of the proper sign is easy. In moist cavity cases of the third stage, and in large dry cavity cases, auscultation readily reveals the true nature of the disease; but there are not a few examples of old, dry, contracting cavities, which by their silence and the absence of positive characters, are not so easily made out, and that require continued examination and repeated exploration. In the fourth stage of the disease, nicety of observation is required. When pulmonary respiration is yet to some extent continuing, which is occasionally the case, the amphoric respiratory sounds may be overlooked, for they are sometimes feeble and restricted, quoad space. The metallic tinkle, too, though present, is liable to pass unnoticed, and the amphoric voice and cough may not be explored at all. But it may be truly said that, with the exception of the very early period of the first stage of phthisis, auscultation, if carefully practised, will never long fail to denote the disease.

Auscultation is either mediate or immediate. The application of the naked ear to the chest to be explored constitutes immediate auscultation. The obvious indelicacy of this practice forms an objection to it. The untidy habits of patients, too, form another. Another objection is derived from the fact that angular projecting or depressed spots do not admit of the ear correctly fitting. Yet it is sometimes advisable to adopt this form of auscultation. The chief occasions on which I have made use of this practice, has been when I have found a patient in bed and unable to sit up above a moment or two. The head of the auscultator may be inserted between the patient and his pillows, and the ear rapidly moved over the whole posterior aspect of the thorax. It is a more difficult matter to insert the head in the same place with a stethoscope half a foot long applied to the ear. Some physicians, I observe, constantly examine the dorsal surface of the chest in this way, and, as the surface is flat, or gently rounded, the ear is conveniently fitted upon the patient, and thus extraneous sounds are denied admission, and the sounds conveyed into the ear are denied exit. Children will occasionally submit to immediate auscultation when they will struggle against the application of the stethoscope. When immediate auscultation is practised, a smooth napkin or towel should be laid upon the chest. In auscultating in this manner, considerable increase of sound or hearing, in force and in resonance or duration, is secured by closing the opposite ear with the finger. The finger is simply to be inserted into the external meatus, or the tragus is to be pressed down upon it. That an increase of sound, or an increase of hearing, takes place when the opposite ear is thus closed, may be at once proved by placing a musical box on one ear and then stopping the other. The sound is heard louder, more resonant, and longer. The sound, too, appears to be heard less in the one ear, and the listener, if he attend carefully, will perceive that the seat of sound appears to travel from the ear in direct communication with the sounding body and to spread over the forehead. The opposite ear is now evidently more involved in the sensation than previously. The explanation seems simply to be this: the sound now in the head is deprived of a means of reduction, viz. by the passage outwards of sonorous undulations in the cavity of the opposite ear. The undulations are retained, and increase the strength and the duration of the sonorous impression or sensation. It seems needless to say that a similar closing of the ear during the use of the stethoscope will be attended with similar results. However, though I have mentioned this matter, I do not conceive that the gain is great, or will, except on rare occasions, be found of much consequence; I therefore do not recommend this practice to be generally adopted. I have seen that some sagacious and practical physicians close their ears in this way when auscultating, but they were perhaps not fully aware at the time of the above physiological explanation of the advantage which they enjoyed.

MEDIATE AUSCULTATION.—Auscultation by means of Lænnec's wooden stethoscope, or some minor modification of it, is pre-eminently the chief form of mediate auscultation; and will probably ever remain such. Nevertheless, modern ingenuity and skilful attention to the requirements of special cases, and the desire to obtain special objects, have succeeded in multiplying the means of mediate auscultation. Besides the wooden stethoscope with its thousand and one specialities, we now have and employ mediate auscultation with the aid of flexible tubes of wire, gutta percha, indiarubber, and even of water.

The wooden stethoscope has received many little improvements since the days of its great author; but its grand properties have not been added to. The wooden instrument of the present day is lighter, more easily taken to pieces, more easily carried, fits the ear of the auscultator better, and is better adapted to the wasted and tender chest.

It is unnecessary to describe, or even refer to, the numerous varieties of the wooden stethoscope now in favour with different physicians. These may be seen at the shops of the surgical instrument-makers. Some of the principal varieties are represented in the wood-cut.



For auscultation of the respiratory and circulation sounds, the hollow wooden stethoscope is the best; but for ascertaining the impulse of the heart or of pulsating tumours, a stethoscope with a flat object end is the most suitable, but this is scarcely auscultation. Perhaps a solid end is better, also in cases of great wasting, for it will come more in contact with the chest than one whose end is simply a narrow border or rim, for such when placed over a deep intercostal space may touch the chest only in a very restricted manner, and obtain only partial sound.

A question has arisen amongst auscultators whether a solid or a hollowed stethoscope answers best for the conduction of sound. Dr. Budd believes that the hollowness and the air are of no value, and Dr. Williams maintains the contrary, and proves that by plugging the hollowed part, sound is reduced. In this case sound is conveyed to the ear by the column of contained air in the stethoscope; but in the presence of much sound conveyed by the solid walls, this is of no moment whatever. The advantage which the hollow stethoscope derives from its hollow condition is simply this:—The solid conducting walls are made better conductors by the freedom which they enjoy to vibrate in consequence of being hollow. The hollow stethoscope is essentially a solid conductor, but it has this great advantage over a solid cylinder that it is more free to accept and propagate sonorous vibrations. That freedom and a certain looseness in the solid conductor are favourable to the conduction of sound, we have only to try in succession a loose porous Malacca cane, a piece of deal or light mahogany, or cedar, and compare the results with those obtained from experiments made with hard lignum vitæ and solid glass or iron. In the latter experiments the sound is greatly inferior. Again, the conduction by means of solid glass is greatly inferior to that of hollow glass or of tubing.

The best materials for the construction of an ordinary stethoscope are light, firm, vibrating woods, such as cedar, mahogany, deal, and lime. Woods which are heavy answer worse: of this class are beech, oak, rose-wood, lignum vitæ and box-wood. The hard heavy rose-wood and lignum vitæ are very inferior. Solid glass being very heavy, is unfit for the purpose, and iron is about the worst material that can be employed. I have nevertheless seen such a thing as an iron stethoscope. The lightest firm woods are equal to the heaviest materials in conducting sound; they are, moreover, easily set in vibration, and unlike heavy bodies they do not suppress sonorous vibrations of the body upon which they are applied.

The sound of a musical box is better conveyed through a light Malacca cane than through mahogany, better through mahogany than rose-wood, better through rose-wood than solid glass and better through glass than solid iron. These facts I have ascertained by careful experiments upon the different materials, and I shall be happy to repeat them to my professional brethren.

Next to the material of which the stethoscope is constructed, the ear-piece is of most importance. It should accurately fit the ear, and care should be taken that the individual conformation of the ear and side of the head be properly consulted. The ear-piece should be large enough to cover the concha, and should close the external meatus. By closing the ear, the sound conveyed by the solid stethoscope to the solid ear, and to the contained air is preserved from external dispersion; the ear-piece acting in fact as the ear-disc of Mr. Wheatstone's microphone. When in use, the ear-piece should be accurately fitted upon the ear.

The object end of the stethoscope for ordinary purposes of phthisical investigation should be one and one third inches in diameter. A smaller diameter may be usefully employed to sink in between the ribs when the soft parts are retracted or greatly wasted, and also in the examination of infants and children. I have already said that a solid object end is of use chiefly in obtaining the impulse of the heart, &c.

The object end of the stethoscope, instead of being circular, is sometimes made oval, sufficiently narrow to fit in between the ribs, which is of moment when the patient is wasted. A curvilinear end has likewise been employed to fit curved or very rounded parts. This is fitted on to a common stethoscope. Mr. Bryant introduced it.

The length of the instrument that suits best for general purposes, is six inches. An instrument only four inches long is occasionally employed, but I have not seen it more applicable in any case than the larger one. It is, however, very portable.

The application of the stethoscope requires some care. It is of great importance that the object end, particularly if hollow, should fit well upon the patient. The hollow instrument must be thoroughly closed to have perfect results. Tilted at one side, however slightly, the result is much impaired. We obtain less sound from the chest, and the sonorous undulations of the contained air which consonate with and promote the vibrations of the solid walls of the instrument are permitted to disperse. A confined column of air in vibration greatly promotes the vibration of the solid walls which contain it. When on account of the wasted condition of the patient or of deformities of the chest, the stethoscope cannot be made to fit so that it shall be closed, various expedients have been employed. Dr. Williams has usefully placed some soft material under the stethoscope, so as to prevent communication with the external air. I think Dr. Sibson has employed paper for this purpose. I myself employ a bag of water or the hydrophone for this object, and I find it answers very well. The water compared with solid is a worse conductor of sound from a solid body to another solid body, it is true; but more than a counterbalancing gain is obtained by the correct fitting to the chest, and the very complete closing of the stethoscope, which are secured.

The stethoscope having been applied to the exact part to be examined, it is held in position by the thumb and forefinger placed about an inch from the object end. The fingers may or may not be applied during the examination. If applied, they should hold the stethoscope lightly, and avoid any movement. After a little practice, the head itself, besides receiving the sounds, may be successfully and advantageously used as a hand to hold the stethoscope *in situ*, and thus to relieve the fingers. In practice, as soon as I have properly adjusted my ear to the ear-piece, so as to have the meatus as nearly as possible in the centre of that part, I remove my fingers. I find myself perfectly master of the instrument, employing my head at once to hear and to hold.

Whether we hold the stethoscope with the hand or with the head, it is incumbent upon the auscultator to press with extreme lightness: for two reasons; first, that he may not cause pain to the patient; and secondly, that he may not suppress the vibrations of the chest and of the instrument. It is to be added also, that strong pressure creates noises in the ear itself, and interferes to some injurious extent with the acoustic freedom of the parts. It is some time before the auscultator acquires great skill in the use of the head, as a holding organ. But great skill is to be sought for, and it is really a valuable accomplishment. Efficiency and delicacy are reconcilable. The management of the head in dealing with the stethoscope is as great a desideratum, as dexterity with the knife is in the case of the operator; and we all know the extreme skill which some surgeons possess compared with others. In a word, the auscultator is bound to endeavour to acquire the same tact in respect of the stethoscope, which Liston possessed in handling his knife. If the physician may ever be excused for being light of head, —light-headed, it is when employing the stethoscope, particularly in cases of phthisis marked with tenderness of the thoracic walls.

In valuing or estimating sounds conveyed to the ear, we are not to conclude that they are necessarily intra-thoracic in their origin. I have heard fine crepitation due to the pressing of the hair of the chest. When much hair is present, the crepitation is greatly reduced by interposing between the stethoscope and the hair, a fold or two of linen, or what is better, the bag of water or hydrophone. I lately examined a gentleman, during whose examination I obtained much hair crepitation, which was ultimately obviated in this way. He had as much strong hair upon the middle of the chest, as we see upon the goat. Friction sounds are liable to be produced by rubbing of the stethoscope upon the chest, but this is less observed in the employment of the wooden than of the double stethoscope of Camman. The young auscultator must guard against this source of error. Friction sounds are sometimes produced by the action of the ear-piece upon the external ear. Sounds, not thoracic, of another kind, are occasionally heard by the auscultator. These are due to certain movements originating in his own ear, chiefly of a muscular character. Such sounds are mostly of ringing, buzzing, and boiling characters. These are induced chiefly when the auscultator's head is kept in a constrained posture. He should therefore, when he hears them, change his position. When I have heard sounds answering to this description, I have also, when it has been possible, requested another to make an examination. I may mention, that when the physician is fatigued and faint with work, these sounds are common. I am satisfied, that after having worked some five hours in the out-room of the hospital, I have heard sounds due more to a tendency to syncope on my part, than to actual disease of the patients. This admission, however, must not be held to weaken the value of sounds really emanating from the chest, and already described, or to cast a doubt upon their thoracic origin.

CHAP. XLIII.

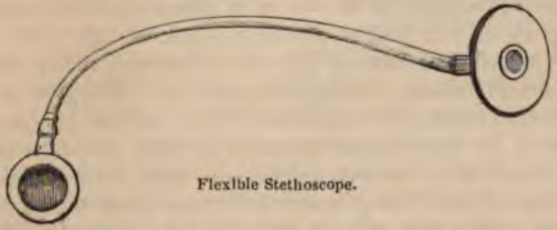
AUSCULTATION — *continued.*

Flexible Stethoscopes. — Bin-aural Stethoscopes. — Dr. Camman. — Dr. Leared. — The Differential Stethoscope. — Poly-stethoscopes. — The Hydrophone. — The Water Stethoscope.

FLEXIBLE STETHOSCOPES. — For the purpose of listening to parts of the chest, which it is very difficult to reach with the ear or with the wooden stethoscope, as, for instance, the lateral regions or the lower dorsal region, when the patient cannot be freely moved, a flexible stethoscope has been employed. This is usually constructed of iron or brass wire, in the form of a hollow cylinder, and covered with thick silk or worsted. The length of this instrument varies, but as usually employed, it is about two feet long. The bore is usually one eighth of an inch. An ear-piece and a body-piece are supplied, as in the case of the wooden stethoscope. As a conductor of sound the flexible stethoscope is inferior to the wooden one, particularly as respects the sounds of solid bodies, and therefore should not be exclusively employed unless it is difficult to reach the patient as above indicated, or unless some special object is desired. The flexible stethoscope is very much an air instrument. Sound is conveyed to the ear chiefly through the contained air. This is readily proven by stopping up the tube. When this is done, little or nothing is heard.

The solid parts of the instrument serve to confine the air and to direct the sonorous undulations not reduced by dispersion, to the ear. Yet it is to be observed that the body or object end is of use in accepting sonorous undulations from the chest, for mere air communication will be of little use. The object end takes on the vibrations, but it fails to transmit them again along the solid and imperfect sound-conducting walls in an efficient way. What it does is this: it throws the air into vibration, the solid walls slightly consonate, and the sonorous undulations thus maintained reach the ear through the column of air. This is different from what takes place with the wooden stethoscope, though hollowed, for we may stop up the tube without materially reducing the sounds conveyed to the ear.

In employing the flexible stethoscope, it is even more necessary than in the case of the wooden instrument to observe that the object end is well applied so as to close the tube. If left partially open, scarcely any sound is perceived. We explain this by saying, that the instrument being chiefly an air one, it is more necessary to confine the air, and we have already said that scarcely any sound is directly conveyed along the solid walls of the instrument.



Flexible Stethoscope.

When the chest of the patient is so extremely wasted as to preclude the exact fitting of the instrument and the complete closure of the tube, much acoustic advantage is obtained by placing upon the chest some material which shall close the tube and fill the hollow parts of the patient. Some advantage is obtained under such circumstances by closing the tube with a fine membrane. A pad of air, or a bag of water,—the hydrophone answers well. The water is better than air, for it is a better conductor of sound from a solid body to a solid body. The hydrophone, under such circumstances, gives a very great advantage. This is very remarkable in dealing with the voice, whether of solid lung or of an excavation.

The physician should possess both a flexible stethoscope and a hydrophone, but they will not often be required in ordinary practice.

THE DOUBLE OR BIN-AURAL STETHOSCOPE. — In the auscultation of the phthisical chest, the uno-aural class of stethoscopes only has been referred to. But besides these a bin-aural stethoscope, the invention of Dr. Camman, of New York, has been frequently employed. I have myself largely used it during the five years I have been connected with the Hospital for Consumption. Of course the chest, in all stages of the disease, has been explored with the aid of this instrument, but it is in the first stage, the early part of the first stage — the suspicious period — that I have found it to be most useful. It is at this period that I believe its powers are most developed, and that its revelations will prove most useful. It is in dealing with fine delicate sounds that this stethoscope is most useful. Such sounds are better heard with the two ears than with one only, which is all that we can employ with the ordinary wooden stethoscope. It is a law that auditory sensations from a given sound are stronger and fuller when obtained by the employment of two ears than when procured by the use of one ear only. The double stethoscope enables us to virtually place both ears upon the same part of the thorax at the same moment. This is the service which Dr. Leared and Dr. Camman have, by their thought and labour, conferred upon us. We gain a fuller and clearer auditory observation than before. The gain is analogous to that which we obtain, when having inspected a fine object with one eye only, we employ both organs.

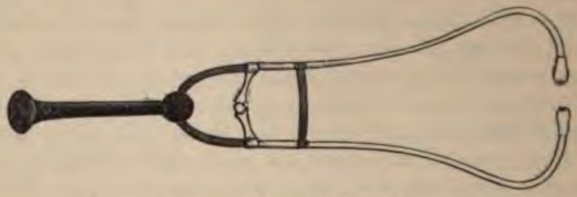
All sounds are better heard with this instrument, but the increase of hearing is most valuable and remarkable in the case of fine sounds with difficulty heard with one ear; these being the buzzing, rumbling, tearing, kettle-boiling, and arrow-root sounds often heard in early phthisis, though not exclusively by any means in this disease. Dry and moist crepitations are advantageously heard with this instrument. I have often made out cracks and slight "pops" with this aid, when I have been very uncertain of their existence with the wooden stethoscope. The fine sounds dealt with by this instrument include the class of sounds most common in the early periods of the first stage of consumption.

In the employment of Camman's stethoscope, it is very necessary that the beginner should avoid nice and absolute decisions. Much sound is frequently obtained from very slight friction of the object end of the stethoscope and the body of the patient. A loud resonance is also heard proceeding from the large cup. Noises in the ear are often produced by the pressure and the presence of the knobs in the ears.

After a little time, however, the auscultator will be educated to the use of the instrument, and its peculiar sounds will be easily distinguished from the sounds of the patient. It is common to hear persons speak with disparagement of this instrument, on account of the little evils above pointed out. But it would be better for such individuals to master a valuable aid than carelessly and heedlessly to throw it aside and to prevent others using it. All instruments require some education and care, even the wooden stethoscope in the hands of a clumsy explorer may fill his mind with prodigious errors. In a difficult, in an obscure pursuit, in dealing with the lives and health of those confidingly placing their interests in our hands, we are imperatively called upon to think seriously and to try time after time before we fling away any contrivance promising assistance in ever so slight a degree. To use skilfully a delicate instrument requires time and application, and this is no more an objection than to the acquisition of a language.

The double stethoscope of Camman consists of two tubes; one for insertion into each ear, and a bell or object end composed of wood, for the collection of sound. The bell is a considerable chamber, about two inches long and one inch or more in diameter. The tubes communicate with this chamber. Steadiness of the instrument is obtained by the greater part of the tubes being formed of metal. Flexibility again is secured by the intervention of flexible tubing between the distal end of the tubes and the wooden chamber or bell. The two tubes are kept in connection by means of a jointed bar. The joint allows of the partial separation and approach of the tubes necessary for adjustment in respect of the ears. A band of elastic material connects the two tubes at a point between the bar and the ear extremities to cause the ear extremities to move into the meatus. The instrument is altogether rather more than a foot long. When employed, the connecting bar is situated a little in front of the eyes. The india-rubber band renders it unnecessary to employ the hands to maintain the instrument in the ears. We sit or stand before the patient and move the object end of the stethoscope from place to place as we think proper, without experiencing any necessity to move the head materially.

The double stethoscope is better adapted for hearing the sounds of respiration than those of the heart. I have remarked that I have distinguished the characters of cardiac murmurs scarcely so well with this instrument as with the ordinary wooden stethoscope.



Camman's double Stethoscope.

The hydrophone, of which I have already spoken in connection with flexible stethoscopes, proves of very considerable use in conjunction with this instrument. Indeed, a trial will convince every one that the value of the instrument is materially enhanced by employing at the same time this simple contrivance. It encloses sound and reduces friction. This instrument is totally useless employed over the clothes of the patient without the hydrophone.

By means of this stethoscope we are enabled to apply, with the greatest ease to the auscultator and to the patient, the principle of bin-aural observation. Until Dr. Camman presented it to us, this principle could not be practically applied. A bin-aural stethoscope certainly existed prior to the one under description, but it rather embodied a principle than rendered it available. Dr. Leared not only contrived a bin-aural stethoscope fully embodying the principle years ago, but he exhibited it in the Great International Exhibition held in London in 1851. (See Catalogue.) I have had the pleasure to examine and use this identical instrument. It is composed entirely of gutta percha. It has two tubes and a body end or hollow cylinder, which receives the distal ends of the tubes. The ear extremities of the tubes have the ear-pieces of the common stethoscope. To use this instrument ordinarily in practice, one would require three hands, for it possesses no self-adjustment, such as renders Camman's so valuable. We require one hand for each ear-piece, and another to manage the body or object end. Thus, while it must be admitted that Dr. Leared greatly preceded Dr. Camman in making known the principle of bin-aural auscultation, it is to this latter gentleman we are indebted for an easy, efficient, and very agreeable method of applying it. Dr. Camman applied the self-adjustment and the ear knobs in 1855.

Before leaving the subject of the double stethoscope, I must add that Dr. Marsh of Cincinnati made in 1851 a stethoscope for the purpose of hearing with both ears, and that he at the same time published an account of it. But it is probable that the idea of hearing with both ears had occurred to other physicians long before any of these attempts. Dr. Williams has informed me that many years ago he was in the habit of exhibiting to his class an instrument which he had constructed for this very purpose.

The double stethoscope, I believe, should be in the hands of every physician called upon to see much chest disease. But it cannot for a moment be held as likely to supersede ordinary uno-aural auscultation.

The pressure of the ear knobs in the ear is often found to be very annoying at first, but practice, and a well-regulated instrument, will remove this objection.

This stethoscope is almost valueless unless applied to the naked body. Over the clothes it possesses very limited power to take up and convey sound. However, this is wonderfully obviated by using the hydrophone. This latter contrivance presses down the clothes and shuts up the bell.

THE DIFFERENTIAL STETHOSCOPE.—The stethoscope so designated, enables the auscultator to collect sounds from two different parts of the chest, consecutively or simultaneously, and to convey them separately to the two ears. The differential stethoscope is one which I believe is capable of greatly aiding us in the detection of early and, physically speaking, ill-pronounced cases of phthisis in the first stage, and also of silent healing cavity cases of this disease. It supplies an easy and satisfactory means of making rapid consecutive examinations of two corresponding parts of the chest, not to be obtained by the naked ears alone, or with any other mechanical aid. Sitting comfortably before the patient, two corresponding parts of the thorax may be examined by the auscultator without shifting his position, without making the slighest movement of the head, with only the most minute action of the fingers, and without the very slightest motion on the part of the patient. Consecutive auscultation of different parts is thus obtained. By this rapid consecutive examination, the slightest differences in the sounds of two different parts of the thorax are made manifest to the mind. And when we remember that in the very first period of the first stage of phthisis, differences rather than absolute characters resolve the question whether tubercle be present, the value of this comparative examination must be manifest.

The differential stethoscope proves of value not only in taking consecutive observations; it affords, as has been discovered in practice, without, if not contrary to expectation, most valuable information when observations are made upon two different parts of the thorax at the same moment. It has been proven, by this instrument, that slight differences in the intensity of the same sounds conveyed separately to the two ears produce remarkable and very striking results. The same sound conveyed to one ear a little *stronger*, and the same sound conveyed a little *weaker* to the other ear, is, or seems to be, heard through that ear only which has the major sound, and not at all through that ear having the minor sound. It is to be borne in mind that the conveyance of sounds to the two ears must be simultaneous. Not only does the sound appear to be heard in or through the ear favoured with the major sound, and not at all in or through the ear supplied with the minor sound, but the parts from which the sound proceeds, according as they are connected with the ear more or less favoured, are sounding or silent.

To be more explicit: a body which sounds in one ear is rendered sensorially silent when the other ear is connected with that body in such a manner or in such a place as to receive rather more sound, the favoured ear seeming to be the only medium or organ through which the sound is perceived, and the place so connected with this ear being the only one which is sounding. Further, lest the idea which we desire to enforce should not be understood, let it be added that a sound audible in or through one ear is rendered inaudible in or through it the moment the same sound is conveyed in greater force to the opposite ear; sound, quoad the first ear, being taken away, and transferred sensorially, so to speak, to the second. Thus, to illustrate this principle physiologically, a weak vesicular murmur sound proceeding from the left side of the chest heard in the right ear is silent, or is lost, quoad this ear, by conveying the stronger vesicular murmur sound of the right side into the left ear in or through which this latter sound is now heard.

By the operation of these two principles: 1st, the consecutive observation of the sounds of two parts of the chest by the two different ears; and 2ndly, by the "eclipsing" of a weaker impression in or through one ear by a stronger impression in or through the other, the differential stethoscope is capable of affording great aid in the discovery of phthisis.

Of the first mode of testing, little need be said, beyond insisting upon the very favourable opportunity this instrument affords of making comparisons. The first observation being completed, the cup used to obtain it is lifted from the body of the patient, and the other cup is momentarily applied. If any difference exist in the force of the sound, in the loudness, in the fineness, or in the duration, or in short, in any appreciable quality, the contrast is immediately made out. This is merely making successive trials, quickly and very conveniently carried out, it is true, with the two different ears. No new principle is involved, if we except the use of the two ears. The case is otherwise in the second method, the simultaneous observation by the two different ears.

The second principle is new and its results are extraordinary. Iteration to some extent, I hope, therefore will be pardoned. I regard the simultaneous method of examining the chest by the differential stethoscope in phthisis, and I may add, in other diseases, of the greatest value. In making auscultatory observations with the consecutive method, an act of comparison is made by the mind. Without this act the observations are totally worthless, and when the difference in sound is not great, and when the auscultator is not greatly experienced, his judgment of the force and loudness and duration of successive sounds may be imperfect. How often in reference to a given sound will one man aver it is louder, and another state it to be weaker, than one that has preceded it! But with the second method no act of comparison is necessary. We have an absolute test — absolute sound or absolute silence.

But to proceed to the practical application of the second principle or simultaneous method. The patient labouring under phthisis, and as most commonly happens, exclusively on one lung, or more in one lung than in the other, has lost the natural symmetry of sound even in the very early period of the very first stage, as has been already described. The inspiration sound has become weak and deficient on the diseased side, while it has either remained healthy or become exaggerated upon the healthy side. If what we have said be correct, and the differential stethoscope be applied to the two sides respectively and simultaneously, we should hear full prolonged respiration sound on the healthy side, and we should observe silence to hold on the unhealthy side. This is exactly what we perceive in practice; we have full inspiration sound in the ear connected with the healthy side, and silence in the ear connected with the unhealthy side. But while the inspiration sound of the lung in the first stage of phthisis is deficient, the expiration sound is heightened and prolonged, and if the stethoscope be still kept in use, we shall have this order of things reversed; we shall now, as I have in numberless examples ascertained the fact, have the expiration sound proceeding from the unhealthy side and silence holding on the healthy side. (See diagram, p. 26.) The ear, which was sensorially filled with the inspiration sound, is now silent; and the ear which was sensorially silent, is now filled with the expiration sound. There is an apparent alternation of sound; during inspiration it is upon the healthy, and during expiration it is upon the unhealthy side: there is also a real alternation of hearing; during inspiration it is obtained, or seems to be obtained, through the ear connected with the healthy lung, and during expiration through the ear connected with the unhealthy lung. This presence of sound on one side of the sounding chest, and this apparent absence of sound on the other side and the perception of sound through one ear and the non-perception of it or silence through the other ear, is represented by the diagrams which are to be found where I have treated of the alterations of vesicular murmur in the first stage of phthisis, and also in my papers on the differential stethoscope, &c., published by the Royal Society and by the Royal Institution, and appended to this work. I may observe that though sensation only is or seems to be procured through one ear only, sound is of course conveyed to both. There is sound in both ears, but the perception of it is obtained only through one. When the simultaneous mode of employing the differential stethoscope is to be made use of, the cups or object ends of the instrument are to be placed upon the two different parts to be examined and compared. When we desire to examine corresponding parts of the two sides, the auscultator must needs be cautious in the selection of the proper spots, for the intensity of sound in health varies within a narrow compass.

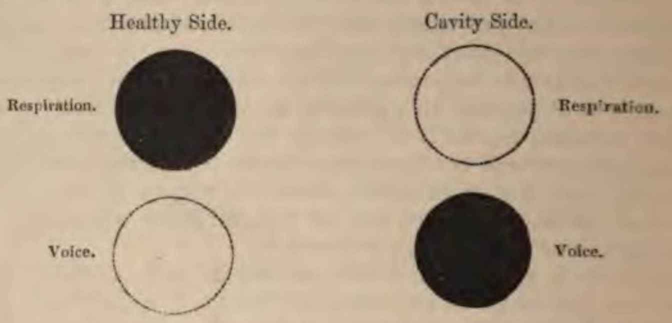
The utility of this instrument as an aid in diagnosis has been fully proved to me during the last four years. During that long period it has been in daily use with me at the hospital, and at home in private practice, so that I can now speak after some experience. I have purposely refrained till now from laying it much before my professional brethren, and until I had very considerable acquaintance with it, believing justly that its virtues and its failings would be best made out by extended employment. I can now conscientiously say, that I believe it to be an instrument which should be in the hands of every practitioner who sees much of chest disease, and whose ears are tolerably equal in acuteness. It will afford him evidence to be procured in no other way, for by no other means is it possible to apply, as we virtually do when using this instrument, the two ears at the same moment on two different parts of the chest, and obtain those singularly interesting and highly valuable results in respect of the correlation of the two ears, and of two auditory sensations or impressions already fully referred to.

When a material difference in the intensity of the sounds of the two sides of the chest is present, I have found this denoted with certainty, when I have been left in doubt in respect of it, when employing the wooden uno-aural stethoscope.

The presence of a silent cavity with little respiration sound has on very numerous occcasions been suggested to me, almost demonstrated, by the use of this instrument, when the employment of the wooden stethoscope, or even Camman's double stethoscope, has scarcely indicated anything positive. The respiration in the cavity has been dry, and has resembled the comparatively noiseless respiration sound of some healthy chests. The differential stethoscope being employed, and in the simultaneous manner, a great revelation has been made, significant and demonstrative of great disease. There has been apparent silence on the diseased side, and full vesicular noisy respiration on the other side. In the ear connected with the diseased side, there has been no heard sound, and in the ear connected with the healthy side, there has been much full and sustained heard sound.

In such cases as those just referred to, viz., silent dry cavity cases, it is remarkable that the voice follows a different order. The voice is heard to proceed from the side which is silent in respect of the respiration sound, and is silent on the opposite side. The ear connected with the cavity hears the cavity voice or cavernous pectoriloquy, while the ear connected with the healthy lung hears nothing: the law of the prevention of sensation in or through one ear having a minor sound, by a major sound in the other ear, coming now into operation. The cavity side gives a louder sound in one ear, and sensorially nullifies the sound conveyed to the other ear from the healthy side.

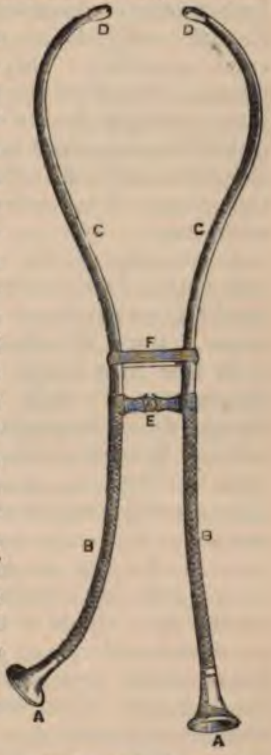
The diagram represents these phenomena. The black circles denote heard sounds: the dotted circles sounds not heard.



The application of the differential stethoscope in a very large proportion of cases, such as have been above indicated, serves in a moment to convey to the mind in a forcible manner, the great fact, that very important disease is present, and that chiefly, if not entirely, upon one side. The mind of the auscultator is struck with the extraordinary difference in respect of the two ears, the one being silent, and the other being as it were filled with sound. Although this remarkable contrast has been observed by me in hundreds of cases of disease, so striking is it even now, that I always attend to it as a most interesting phenomenon. I have observed with much satisfaction, the pleasing surprise which auscultators have evinced on first becoming practically acquainted with these sensorial facts.

But it is not merely respiration sounds which are thus contrasted. The heart's sounds, whether merely heightened, or positively new and adventitious, are similarly tested by this instrument. By placing one cup upon the second right space, and another at the fifth left space, we are enabled to say whether the sounds are louder above and on the right than below and to the left. If a good sized cavity be present in the right apex, the sounds of the heart are heard at that point only, and not at all at the apex. Therefore, if in a suspected case of phthisis the sounds are so heard, we may pretty safely conclude that phthisis in the third stage is present. This presumptive conclusion must of course be further tested. In dealing with murmurs of the heart, too, this instrument is available, and as they are by no means uncommon in phthisis, it may be permitted to say a few words here on their auscultation by means of the differential stethoscope. If we desire to know whether a murmur be basic or apicial, all we have to do is to place the two cups respectively over the base and the apex. If the murmur be basic, the sound is heard to proceed from that part only; and if it be apicial, from *that* point only. This restriction to one part will hold, although upon uno-aural exploration, the murmur may be heard at both places. This restriction of heard sound is due to the law already noted, viz., that a major sensation or sound through or in one ear sensorially nullifies a minor sound in the other ear.

The differential stethoscope has two tubes; one for each ear, and instead of communicating with one collecting cup only, as in the case of the double stethoscope, they have each a separate cup A A. It presents a separate stethoscope for each ear. They are mechanically combined for facility of management, but they are in an acoustic sense, totally separate. The tubes are partly made of metal C C, and partly of elastic tube B B, to admit of some degree of motion. The two tubes are connected together, as in Camman's stethoscope, by a jointed metal bar E, and an india-rubber band F. In fact, the mechanism of Camman's instrument, which is beautiful, has been completely adopted. The aspect of the two instruments is therefore much alike, and by a superficial observer the two stethoscopes are sometimes confounded. This instrument has two ear knobs D D for insertion into the respective ears.



Differential Stethoscope.

The principle of Camman's instrument, and indeed of any other double stethoscope, is very different from that of the differential stethoscope. The double stethoscope enables us to hear the sound of the same part with both ears, virtually to place both ears upon one part of the chest, and thus receive a simply heightened sensation; the differential stethoscope enables us to do more than this, we hear the sounds of two parts at the same moment, and virtually place our two ears upon *two* different parts of the chest at the same instant, obtaining the sensorial results above related, illustrating too, in a remarkable manner, the correlation of the ears, and their respective impressions.

But the differential stethoscope is useful not only used simultaneously. It may be used, as has been above stated, to collect observations consecutively. In addition to this, the differential stethoscope can be converted into a simple double stethoscope, by merely placing both cups, — equivalent to ears, — upon the same region of the chest. We have then the only advantage of the double stethoscope, a heightened sensation. My stethoscope has the advantage of Camman's in this respect; for while mine can be converted into a simple double stethoscope, the double stethoscope cannot be converted into a differential one, to be employed simultaneously, for it has only one cup, and consequently the means of collecting sound from one part only at the same time.

In employing the differential stethoscope, I generally follow this order of procedure. I seldom use it however, until I have examined the patient with the wooden stethoscope. I place both cups upon the suspected side, using it at first as a simple double stethoscope. I take note of the respiration sounds, the inspiratory and the expiratory. I observe forced inspiratory phenomena. Coughing bruits are taken. The voice then is attended to. I do the same thing with the opposite side. Having in this way obtained the absolute characters of the respiration and voice sounds, I now place the two cups upon the two sides, above. The respiration is heard; generally the respiration murmur is heard on one side only; the healthy or comparatively healthy side: on the side which is silent, quoad the respiration murmur, moist crepitations and gurglings are often heard. Coughing causes much explosion gurgling sound to be heard on the diseased side. The voice in cavity cases is heard with some exceptions already stated, on the diseased side only. Having examined the parts above and below the clavicle, I examine the mammary and infra-mammary regions. The middle parts of the two lateral regions are with difficulty examined simultaneously, on account of the want of length of the instrument, but the anterior borders may be thus treated. Having explored the front, I now proceed to examine the whole dorsal aspect of the chest from above downwards, keeping as much as possible to the same order as I observed in respect of the front aspect.

With respect to posture, I may say, that if the patient be pretty strong, and of nearly the same height as myself, I examine him standing, but if weak or much taller or much shorter than myself, I examine him in a sitting posture. If very weak, the patient has to be examined in bed; the lying posture in this case is best for examining the front and the lateral regions. The back is with difficulty examined; we must endeavour to place the head as nearly as possible at the middle of the back, the patient inclining forward. It is of great importance that the head of the auscultator should be exactly opposite the middle of the thorax, and not turned to either side.

With respect to the instrument,—both ear-knobs must be equally well fitted into the ears. If one be ill-fitted, and the other be well fitted, of course differences in hearing will arise, independently of disease. They are to be directed upwards in the ears. The two tubes are to be kept in the same state. Care is here particularly required in respect of the flexible parts. One should not be less straight than the other. Both should be kept perfectly straight, otherwise the conduction and propagation of sound may be greatly interfered with. Lastly, the cups must be similarly dealt with. They must have corresponding parts of the chest, and they must be held steadily, but gently, *in situ*. They are best held with the thumb and forefinger upon each cup respectively, and near the commencement of the flexible part of the tube. The fingers and hands must on no account touch the chest of the patient. Care is to be taken that the cups and tubes do not come in the very least degree in contact with ribbons, ringlets, &c. Examinations with this instrument over the clothes are very unsatisfactory. When this mode of examination cannot be avoided, the hydrophone will give the exploration some value.

Before leaving the subject of the differential stethoscope, I shall take the liberty of stating that Dr. W. Marsden, of Quebec, has reprinted in the British American Journal my paper upon this instrument, published by the Royal Society, and that he makes the following observation upon this new stethoscope. "Having procured this instrument, I have since had many opportunities of testing its usefulness. In affections of the heart, in particular, it has afforded the most satisfactory results. In fact, no medical practitioner who professes to treat diseases of the chest, ought to be without it. The important character of the paper will, I trust, be a sufficient excuse for its length." (P. 337.)

A word as to the construction of the differential stethoscope. It is most important that the maker should secure perfect acoustic equality in the two parts of the instrument. The physician should carefully examine the instrument himself. It was only the other day a differential stethoscope was sent to a friend of mine in the country, which quite perplexed him. He had sound at one part, and silence at another. He first feared great disease on the part of the person examined, but his fears were immediately after directed to his own sense of hearing: he concluded he was deaf of one ear. After a little examination of the instrument, however, he was greatly relieved to find that the flaw lay neither with the patient nor with himself, but with the instrument. One tube was completely blocked up. No air could be made to pass through it. The maker had allowed some molten glue to pass into it. Mr. Coxeter of Grafton Street, it is but justice to say, greatly aided me in respect of this stethoscope, and that he has succeeded in making a very pretty instrument, and one which has philosophical as well as medical applications.

THE POLY-STETHOSCOPE.—A stethoscope which may be so designated has been occasionally employed. M. Landensy of Paris, in 1850, constructed a stethoscope with one bell, and several tubes, for the purpose of permitting several persons to hear the same sound. This instrument has been found useful in teaching auscultation to a class. A double poly-stethoscope which gives two tubes to each hearer, I have myself constructed; and there is nothing to prevent a poly-differential stethoscope being made, viz., one with two bells, or cups, and with two tubes for each observer. But it will I fear be thought that we are now threatened with the plague of instruments.

An error is prevalent to some extent amongst professional men, and widely spread amongst non-professional persons, that the stethoscope of the physician intensifies or augments sound. It is believed that the sonorous undulations of the chest are multiplied by the instruments which we use. This is not the case. Were the ear to fit well upon the patient's chest, no acoustic advantage would be gained by employing stethoscopes. When the ear cannot fit well, and the stethoscope on the other hand does so, then more of the sonorous undulations are taken up by the stethoscope than by the ear, and it is in this way that an increase of heard sound is effected. The stethoscope makes a given amount of sound rather more available to the ear of the auscultator, and this service, and the cleanliness and delicacy of the instrument, are sufficient reasons for its employment, and an ample answer to those objectors who will only employ the ear, and deprecate instrumental aid.

THE HYDROPHONE. — The hydrophone which has been referred to on several occasions in the course of this work, is under some circumstances an aid in auscultation, and is therefore deserving of some notice in this place. It is a small bag, about the size, and the exact shape of a good sized watch, filled with water.

This little contrivance was prepared by myself for the purpose of aiding flexible stethoscopes, or stethoscopes whose chief medium for the propagation of sound is the contained air. I had found that sounds of solid bodies were better heard through flexible stethoscopes, or hearing tubes, when water was interposed between the sounding bodies and the hearing instruments. The results of experiments made by me in connection with this subject are contained in a paper which I published in 1859 in the "Medical Times and Gazette." As this paper contains matter of some importance and interest in respect of auscultation, I have ventured to reproduce it at the conclusion of this work. The paper is entitled "The Employment of Water in Auscultation."

The Hydrophone.

In practice I am willing to admit that the hydrophone has not proved so serviceable to me as I had found it in dealing with the sounds of solid bodies, such as wood, stone, and metal. In the case of these bodies, great advantage was obtained by water, whether alone as a film, or ring round the edge of the stethoscope, by filling up the intervals which existed between their surfaces and those of the hearing tube. However fine and plain the surfaces of these sounding bodies were, and however well finished the wooden stethoscope migh be, interstices or intervals existed between them which permitted of a certain amount of communication with the external air, unfavourable to confinement of sonorous undulations. In the case of the thorax, no such interstices exist, or if they do, they exist to a much less extent, on account of the soft and elastic nature of its coverings. The liquids which enter into the composition of the integuments of the chest, in fact, perform, though less perfectly for the stethoscope and the chest, the part of the water or the water bag in my experiments with water upon wood, stone, and metals.

Yet it must not be conceded that the hydrophone, even upon the naked chest, is not of some value. When the skin is dry and uneven, it increases the sensation of sound. When the surface is irregular, as between two ribs, the interspace being sunk, the hydrophone is of great use. When it is inconvenient to undress the patient, the hydrophone confers a value on the flexible stethoscope unknown to it in its unaided simple condition.

Alone as an auscultatory instrument, nay, as a stethoscope itself, the hydrophone is not without value. In obviating, in filling up, sunk parts in greatly wasted subjects, it is useful. In filling up the meatus auditorius, when it is impossible to apply it exactly to the patient's chest, on account of irregularity of surface, it is also useful. The service which the hydrophone confers upon the ear, by filling up depressions in the chest of the patient, and by filling up and closing the external ear of the auscultator, in many cases more than counterbalances the loss incurred by water being a worse conductor of sound to a solid body than a solid body such as the wooden stethoscope.

With respect to the hydrophone, I would say, it is more an acoustic than a stethoscopic instrument, and though it may be employed in some few cases as a stethoscope itself, it is chiefly valuable as an aid to flexible stethoscopes. As it costs next to nothing, as it may be useful in medicine, and serves to illustrate certain laws in physics, it should be in the study or armamentorium of every physician. As I recommended caution in the examination of the differential stethoscope itself, I have to do the same thing with the hydrophone. Sir Alexander Morison, my kind friend, being desirous of repeating some of my experiments with this contrivance, very recently went to a maker and asked for it. Sir Alexander showed me the thing given him, and I found it was more a bag rattle than a water bag. It contained only a teaspoonful of water to some two ounces (by volume) of air. When shaken it was calculated to amuse a child, but as a hydrophone it was utterly useless. I at once discharged the air, and replaced it with water, and succeeded, to Sir Alexander's amusement, in obtaining the acoustic results above indicated. It is exceedingly likely that the many failures in experimenting with new apparatus which we hear of, arise from similar causes, and we should therefore be slow to decry the results of others, because we ourselves do not at once arrive at them, but carefully look to the efficiency of the means with which we are experimenting.

The application of water in auscultation was experimentally made by Mr. W. Garstang, of Bradford, some years ago. In 1855 that gentleman addressed a note to the editor of the "Medical Times and Gazette." After referring to the recommendation of a school-boy, to place his ear beneath the surface of water and listen to a bell sounded in that liquid, he says that he filled the shaft of his stethoscope with water and listened with it. He adds, "I now found the instrument to be capable of transmitting the current of sound with increased clearness if not force." Mr Garstang, in thus filling his stethoscope, certainly made a laudable experiment, but was in danger of spoiling the instrument, both mechanically and acoustically. Water is a good conductor of sound certainly; but in the conveyance of sound from a solid body to another solid, it is much inferior to hollow wood. Hollow tubes thus employed have their vibrations interfered with when filled with liquid. I have seen an auscultatory curiosity, in the shape of a wooden stethoscope, supplemented by two small wooden cylinders containing water. This was lent me for trial by Dr Powell, but of course it possessed no acoustic advantage. If water is to be employed at all, it is alone, as with the hydrophone, or as a supplement to air instruments, as has been already described.

CHAP. XLIV.

Measuring the Movements of the Chest. — The Hand and Eye. — The Tape Measure.—Dr. Hare's double Measure. — Mr. Henry Thompson's Measure. — Dr. Sibson's Chest Measurer. — Dr. Quain's Stethometer.—The Pneumatoscope. — The Sphygmosphone. — Callipers. — The Chest Goniometer. — Spirometers. — Microscope.— Exploring Needle.

THE movements of the chest are to be gauged by other means than the eye. The hand, and various instruments, are applicable for this purpose. The hand, delicately employed and educated, is sufficient to ascertain the fact of diminution or decrease of movement. But for the ascertaining of degrees for present use, or for future comparison, the instruments to be presently noted are extremely useful. In examining cases of phthisis, the hand may be employed under almost any circumstances, for it gives no pain, and occupies only a moment of time. To determine the movements of the upper front of the chest, the part almost invariably first found to be deficient, the flat palm of the hand should be placed upon it. When we desire to compare the movements of one sub-clavicular region with another, I find it is a good plan to place the tips of the three middle fingers of each hand respectively upon corresponding parts, and observe the motion communicated to the hand. A material deficiency is readily demonstrated in this way. To determine the expansion and contraction of the lateral regions, we place the extended hands upon the two sides. When material deficiency exists on one side, the arm corresponding with the hand applied there is comparatively motionless, while the arm corresponding with the other hand is freely raised and freely depressed. When the hands are so employed, the patient should inspire deeply. When percussion sounds above are but little altered, and while auscultatory phthisical signs are ill pronounced, it often happens that a considerable deficiency of the motion of expansion of the ribs is discovered. This indicates the necessity for strict exploration. Some material morbid condition exists on the deficient movement side, and further inquiry must determine its precise nature.

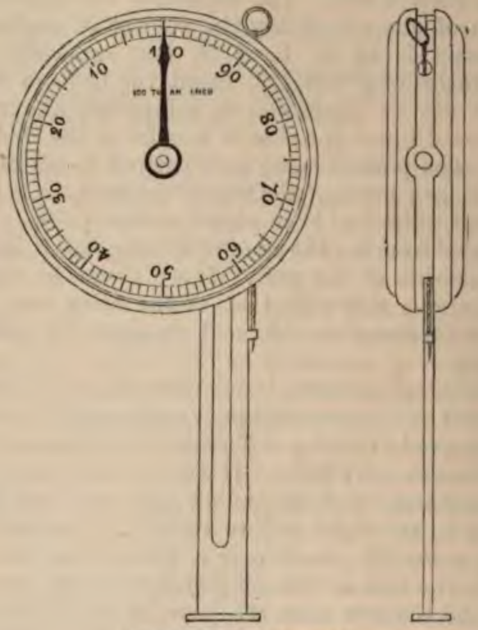
The instruments which have been applied to determine the amount of motion, or to make it very obvious to the eye, are rather numerous. These are the ordinary tape measure, Dr. Hare's and Mr. Henry Thompson's double tape measures; Dr. Sibson's chest-measurer, Dr. Quain's stethometer, and my own sphygmoscope or pneumatoscope.

Of the common tape measure nothing need be said explanatory of its construction. But the mode of applying it deserves a word or two. The expansive movement outwards of the ribs of one side being the subject of exploration, the tape measure is to be fixed by one extremity upon the spinous process of a vertebra, about the level of the nipple. When the act of expiration is completed, the measure is quickly passed round the side to a point at the middle of the sternum. The patient being now desired to fill his chest, or to "draw a long breath," the tape at the sternum is slackened, and the part which had been placed at that point is permitted to be dragged from it: the amount of dragging is the measure of the expansion of the side. If we desire to compare the expansion of one side with that of the other side, we repeat this process on the other side, and compare the two amounts of dragging.

Dr. Hare's tape measure is a double one, and a very useful instrument it is. I have constantly employed it. It may, like my stethoscope, be called a differential instrument, for it indicates differences very fully. It consists of a tape with the inches numbered, and beginning from the middle. The figures pass to the right and to the left. The middle point, or zero, is generally placed over a spinous process of a vertebra, as in the case of the employment of the common tape measure, and the two ends are brought round the two sides respectively to a point at the middle of the sternum. The exact measure is taken at the end of expiration, and this being noted, and the patient now having drawn a deep breath, the extremities are allowed to drag, and the fresh measurements are taken. We now compare the amount of dragging on one side with that upon the other. The point at which the middle of the differential tape measure of Dr. Hare shall be fixed need not be the spine. If it suits the views of the physician, the starting-point may be made the middle of the sternum. By middle of the sternum I do not mean the point between the top and bottom, but a point equidistant from its lateral borders.

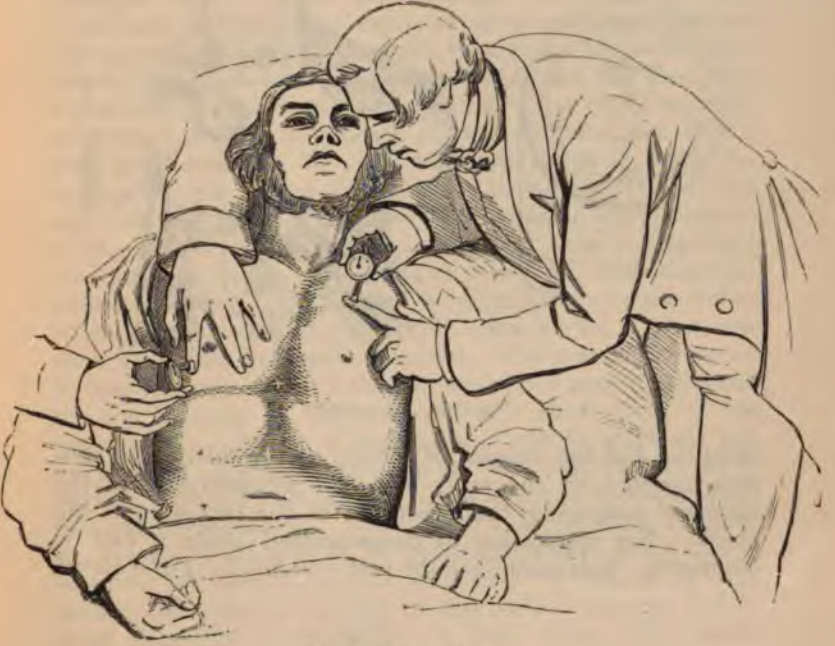
Mr. Henry Thompson's tape measure is much the same as the above, but it is provided with a little saddle to fit upon the spine, and a middle plate to be fixed upon the sternum. The ends of the measure are passed through this. This fixed point aids in marking the amount of dragging.

Dr. Sibson's chest measurer.—This instrument, the first of the kind, is useful when we desire to compare with exactitude the degree of elevation of different parts of the thorax. It is extremely delicate, and in comparative mensuration it affords results highly satisfactory, both for present purposes and for comparison with future observations on the same patients. In shape and size this instrument resembles a watch. It is supplied with a rack, which is movable. When this rack is moved by the elevation of the chest, an index travels upon a dial on the face of the watch-like instrument, and the degree of motion of the chest is thus indicated. The revolution of the index represents the motion of the chest to be an inch, and the dial being divided into one hundred parts the one hundredth part of an inch movement may be obtained and registered. This instrument is brought in contact with the chest only by its rack or bar. The rack may rest upon the finger placed upon the chest. The hand holding the instrument must be fixed. Localized movements are well suited for observation with this instrument.



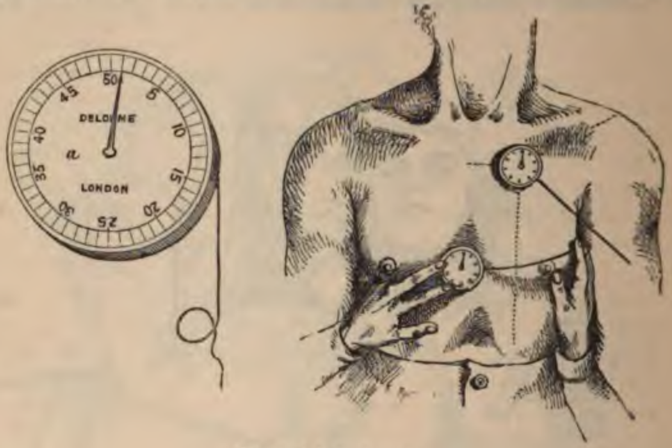
Dr. Sibson's Chest Measurer.

Through the kindness of Dr. Sibson I am enabled to illustrate this subject by the accompanying wood-cuts, exhibiting the instrument and its application to the chest. See vol. xxxi. of "Medico-Chirurgical Transactions."



Dr. Sibson's Chest Measurer.

Dr. Quain's stethometer. — Dr. Quain's stethometer is delicate and easily managed. It, too, resembles a watch, having a dial and index. The index is moved by a silk thread, instead of a rack or bar, as in Dr. Sibson's instrument. The silk cord proceeds from the side of the watch-like instrument, and is extended over the part of the chest to be measured. The instrument is laid flat upon the chest, and the silk is held at the further extremity of the part whose motion is to be taken. The silk cord, during the expansion and swelling of the chest, is dragged upon an axle in the instrument, and the index connected with the axle denotes the mount of dragging. This instrument possesses the great advantage, that while it is applicable to strictly local and restricted movements, it is suitable for measuring the expansion of an entire side. Thus, the dial being placed upon the sternum, the silk cord may be made to pass over the chest to the spine. An inspiration after a forced expiration will give upon the dial the amount of motion of the side. This process repeated on the other side will accurately afford the means of comparing the expansion of the two sides of the chest. For application to circumscribed spots a foot is employed. This rests upon the part examined. For a clever and full account of this instrument and of its capabilities I refer to a paper by the inventor contained in the "London Journal of Medicine."



Dr. Quain's Stethometer.

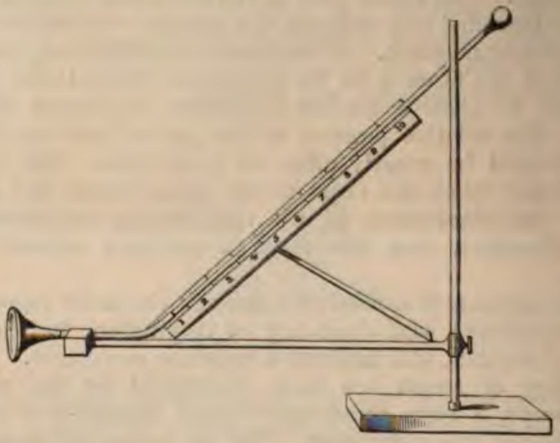
Foot of Stethometer.

The hydrostatic pneumatoscope, as my sphygmoscope may be styled, when applied in the measurement of the respiratory movements, indicates remarkably well the rise and fall of the chest during the acts of respiration. It consists, so to speak, of a small projecting mamma of water. The liquid is confined in a cup made of glass or other solid material, like the body-piece of the wooden stethoscope, and covered over at its mouth with an impermeable membrane of india-rubber, or some such material. To the narrow extremity of the stethoscope-end-like cup a few inches of india-rubber tube is fitted, and to this again a graduated glass tube is attached, having a bore of about one-sixth part of an inch. This glass tube is kept in an erect, or nearly an erect, position. The cup containing liquid is made to occupy a horizontal position by being fitted into a wooden frame, and the glass tube is retained *in situ* by the same means. The cup is made so as to move slightly, in order to fit the form of the chest in a convenient manner. The liquid is supplied so as to fill the cup, and to rise in the tube a little above the level of the cup. By means of the pressure thus obtained, the membrane at the mouth of the cup and the water form a projecting mamma, sensible to the slightest touch. I find that the mamma is much better formed by employing common india-rubber membrane than vulcanized material, for it gives way more under the hydrostatic pressure. The stand, which must be heavy,—say, loaded with lead,—is placed upon a table, and the cup is made to touch the patient's chest when he has expired fully. An act of inspiration is now to be slowly and fully made. The liquid rises in the tube, and the number of degrees travelled over indicate the amount of thoracic elevation and advancement. When one side of the chest has been examined, the other is to be proceeded with. Great care is required to observe similar conditions in respect of both sides. The relative position of the patient and the instrument should be exactly alike on both sides. The instrument must touch the chest to the same extent and in the before the observation of the rise, during inspiration, is same direction, and the chest must have expired fully taken.

This instrument applied over the sub-clavicular region of a patient affected with deficiency of respiration, in the first stage of phthisis, will indicate a deficient movement. When deficiency of sound has been ill-denoted by the wooden stethoscope, I have occasionally found deficiency of motion by means of this instrument. But in respect of diagnosing early phthisis, the differential stethoscope is much more valuable than the pneumatoscope. Nevertheless, it seems right to refer to every reasonable mode of investigation. I would by no means recommend this instrument in the ordinary examinations of patients; but unless we know something of it we shall not be able to employ it in exceptional cases, or when its testimony may for some reasons that may occur, prove of service.

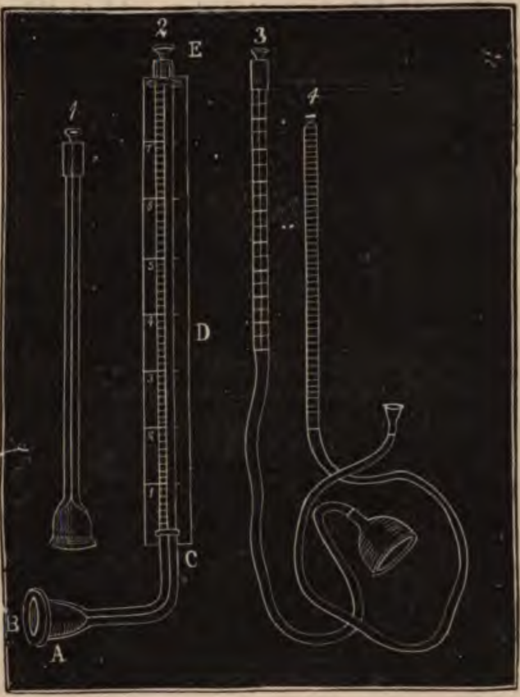
The amount of time employed in the act of inspiration, I may mention, is well denoted by this instrument. The short time of inspiration and the prolonged period of expiration in phthisis are made very manifest by the rapid ascent and the slow fall of the liquid in the tube.

This same instrument possesses some value to the scientific physician, in making obvious to the eye the movements of the heart, when that organ is displaced, as is so often the case in phthisis, in the third and fourth stages. When the heart is near the surface, it can generally be felt and seen at the second interspace on one or other side; but when it is still covered by some pulmonary structure, or when the cavity is small, the application of the sphygmoscope, for it is now a sphygmoscope (sphygmos, pulsus cordis), will render the obscure impulse more manifest. The liquid is more sensible, so to speak, to the motion of the heart than the eyes of the observer. In other words, the liquid set in motion in the tube is more obvious to the eye, than the motion of the chest caused by the underlying heart. The mamma is not sufficiently indicated in the cut.



Pneumatoscope.

When the heart's impulse is to be tested by the application of the sphygmoscope, a modification of the instrument may be employed, though its manifestations are less delicate. The stand may be dispensed with, and a glass cup and tube alone employed. A piece of flexible tubing may be interposed between the cup and the glass tube: this admits of more free movement of the instrument, and is calculated to reduce the chance of breakage. See engraving representing sphygmoscopes, fig. 3:—



Sphygmoscopes.

Fig. 1. Artery sphygmoscope. Bore of tube 1-16th of an inch.

Fig. 2. Portable heart sphygmoscope. A, Glass cup, containing coloured water. B, Lamina of india-rubber, covering the mouth of the cup. C, Glass tube; bore 1-10th of an inch. D, Graduated scale. E, Screw-stopper.

Fig. 3. Heart sphygmoscope supplied with india-rubber tube, to admit of greater facility of comparison with movement of artery sphygmoscope, and greater readiness of observation when listening to the sounds of the heart.

Fig. 4. Artery sphygmoscope, with india-rubber tube.

The determination of the time of murmurs of the heart in phthisis is aided by this instrument. If we listen with the differential or double stethoscope for the sound, and look at the same time at the sphygmoscope, we can at once tell whether the murmur be systolic or diastolic. Every murmur heard during the ascent of the liquid is systolic, and every murmur heard during the descent is diastolic. I may mention the fact, though perhaps a little out of place, that if the differential stethoscope gives heard sound or makes it appreciable, at the base, the murmur is basic; and if at the apex, the murmur is apicial.

As these instruments are comparatively little known to the medical world, I have ventured to add to this work my papers upon them, published by the Royal Society and "The Medical Times," and a plate taken from the "Archives of Medicine." It is remarkable that this very morning (Nov. 2, 1860) I have received from my kind friend Dr. C. B. Williams, a copy of the work of M. Groux, on the subject of Fissura Sterni, and that I find in it a drawing of my sphygmoscopes. It also contains an extract from a paper by Dr. J. B. Upham, of Boston, United States, read before the Boston Society for Medical Improvement, and published in the "Boston Medical and Surgical Journal." As the extract contains perhaps more trustworthy testimony than any that I could myself bear to the merits of these instruments, I would here insert it. "The delicate and beautiful instrument of Dr. Scott Alison, of London, called the sphygmoscope, has added much to the facilities of determining this vexed point"—the synchronism or non-synchronism of the various motions of the heart and great vessels as displayed by M. Groux. On perusing the work of M. Groux, I am greatly struck to find that the sphygmoscope has been converted into an acoustic appliance, and is made to act even upon the ear. This remarkable result has been achieved, to his great honour, by Dr. Upham, by the application of an electro-magnetic machine with a bell attached to it. As the liquid in the sphygmoscope rises, it breaks contact in the electro-magnetic machine, and a hammer falling upon a bell a sound is instantly obtained. The successive movements of sphygmoscopes applied to different parts of the heart and the arterial tree are signalised by successive sounds. To the courtesy of Dr. Williams I am indebted for an opportunity of witnessing and hearing these very remarkable and novel results. On the 2nd Nov., 1860, I witnessed the operation of the sphygmosphone of Dr. Upham upon the heart of M. Groux, at Dr. Williams' house, when Dr. Quain was also present.

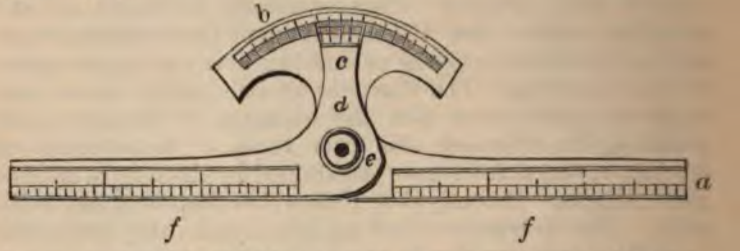
The surprising and brilliant feat has been accomplished with the aid of the sphygmoscope and an electro-magnetic instrument, to record through the medium of the wires of an electric telegraph, the movements of the heart, at a distance of three miles and a half. This experiment, performed by

Dr. Upham upon M. Groux, was accomplished successfully in the United States of America last year. While M. Groux sat in Boston the movements of his heart were recorded at Cambridge.

A pneumatoscope has long been employed to ascertain the pressure of the expired air. The construction and principle of this instrument are altogether different from those of the instruments I have been describing.

To MEASURE DIAMETERS. — Dr. Stokes and other physicians have recommended the employment of callipers for the purpose of taking diameters of the chest. In treating of the shape of the chest in phthisis, notice has been taken of depression of the anterior and upper part of the chest. To measure the amount of depression and the reduction of the cavity of the thorax, none of the instruments already noted are well adapted. There may be much depression, and yet it would be difficult to measure or even to demonstrate it, by means of the tape. A depressed part, too, may possess an amount of motion which would prevent Dr. Sibson's and Dr. Quain's chest measures proving of any avail. The hydrostatic pneumatoscope is liable to the same objection. Callipers answer well, however. One extremity is placed on the scapular region, and the other upon the infra-clavicular region, the limbs bridging or arching over the upper aspect of the shoulder. The diameter of one side is taken, and then we proceed to take the diameter of the other. In phthisis, the diseased side ever tends to a reduction of diameter, and this we have ascertained by the employment of the callipers. Recently Dr. Nelson has improved the callipers. This instrument has a graduated scale, very serviceable in delicate and comparative measurements of the thorax.

To MEASURE ANGLES AND CURVES OF THE CHEST.—The only instrument by which angles and curves are measured is the stetho-goniometer or chest goniometer, which I myself introduced into use. I have found it serviceable to measure deviations from the natural form of the chest, so common in all stages of phthisis. The measurement at different periods of the progress of the same case serves very accurately to indicate the degree of alteration, of increase or abatement of deviation, which may have taken place. The chest goniometer consists of two arms revolving upon a central joint, meeting at various angles as they are made to separate from or to approach each other. Connected with the central point of one of the arms is attached an arc duly graduated, and connected with the central part of the other arm is an index, which moves along the graduated arc, as the arms are made to approach or separate from each other. The index points to the degree upon the arc, and denotes the angle formed by the meeting of the two arms. The parts which offer themselves most for measurement are the infra-clavicular regions, and the junction of the sternum and the costal cartilages, and the junction of the costal cartilages and the ribs. In speaking of the alterations of the form of the chest in phthisis, I have already pointed out that flattening is a very frequent occurrence in the first stage of phthisis. In this case angles are not usually to be found, the alteration rather consisting of a loss of roundness, or of the normal curve. We have, therefore, in measuring this deviation with the chest goniometer, to take the curve, and not an angle. To take curves is more difficult than to take angles, which is extremely easy. Angles are by no means of uncommon occurrence at the articulations, indicated above, in the advanced periods of phthisis. These are easily measured. The same method is applicable to them as in the case of the angles of crystals, &c.



Stetho-goniometer, for measuring the inclination of different parts of the walls of the thorax in cases of disease.

aa. The arms. *b.* The arc of a circle, graduated from 120° to 220°, the latter degree being on the left hand. *c.* The vernier, with an arrow at zero; the index of degrees. The vernier is divided into 12 equal parts, the whole being equivalent to 1° on the arc, or to 60′. *d.* Vernier arm. *e.* Joint. *f.* Inches and 10ths of inches, marked by lines, which when brought into line by bringing the two arms nearly together, would determine the 1st degree, if instead of an arc it had an entire circle.

At the conclusion of this work I have ventured to reproduce my papers on the chest goniometer, and on the deviations from the natural form of the chest, published in the "Archives of Medicine." The reader will there find directions for using the instrument and some of the results obtained by its employment.

To MEASURE THE SO-CALLED VITAL CAPACITY.—For many years experiments have been made with different contrivances to measure the air exhaled in expiration.

The amount of air inhaled may be ascertained by simply placing a given quantity of air in a graduated glass vessel placed over water, and by means of a tube communicating at one end with the mouth of the patient, and at the other with the air in the glass vessel. The quantity of air displaced or removed indicates the inhaling capacity.

In measuring the air-capacity of the lungs, it is usual to make observations rather upon the amount of air expired than upon that inspired. Dr. Hutchinson's, Dr. Pereira's, and Mr. Coxeter's spirometers are all constructed upon this principle.

When we measure the amount of air respired or expired, we should bear in mind that in phthisis, in the fourth stage, a portion of the air so observed has simply passed through the lungs, and proceeds to or from the pleural cavity, the lung being deprived to a very great extent of its air capacity. The air inspired or expired, in the fourth or perforation stage, is the measure of the air capacity of the lungs and pleural cavity, and not of the lungs exclusively.

DR. HUTCHINSON'S SPIROMETER.—This instrument measures the amount of expired air. It consists of a metal cylindrical vessel open above, like a narrow pail, about two feet high, and about ten inches in diameter, filled with water, into which another cylinder, having an aperture above and open beneath, is inserted, and so much smaller as to move freely within it. The latter, when an observation is to be made, has its upper part brought down to the level of the water in the first or enclosing cylinder. When this is done a plug is fitted into the opening in the top of the second cylinder to confine the air which is to be breathed into it. A flexible tube communicates between the mouth of the patient and the smaller or movable air-receiving cylinder. The air breathed out is conveyed into the smaller cylinder, and the water in the larger cylinder, preventing the escape of the air, the smaller cylinder is forced upwards. The cylinder, of course, rises to an extent corresponding to the amount of air expired into it. To the rising cylinder an index is fixed, which points to a graduated fixed scale connected with the larger cylinder, and by this means the quantity of air contained in the smaller cylinder is indicated, and at once read off. The plug of the smaller cylinder is removed when it is desired to discharge the air from it, and to enable it to descend again into the larger cylinder to be ready for another expiration. The cylinder is pressed down into the water, and the air escapes by the aperture to which the plug had been previously attached. The mechanism of this instrument is extremely simple. The small cylinder, when prepared for operations, is simply a vessel filled with water. The air expired passes into it, and as the water in the larger or containing cylinder cannot be got rid of, the smaller cylinder, which is readily movable, is forced up under the pressure of the entering air, which it now receives. I observe in Dr. Tanner's "Clinical Medicine" the following remark: "On respiring through the mouth-piece, the air passes into the lesser cylinder, and causes it to rise by displacing the water," p. 42. Now the only displacement of water which takes place is by the operator forcing down the small cylinder into the larger one without removing the plug to permit of the displacement of the air. Indeed, if the water were freely displaced, the smaller cylinder would remain stationary.

The displacement of water is fatal to our experiments. I have, I may remark, described Hutchinson's spirometer from the specimen we have at the Hospital for Consumption, and which I have always believed to be a good one. Possibly the instrument which Dr. Tanner has described was an early and less happy effort of the inventor.

The instrument as above described is adapted to a suitable stand.

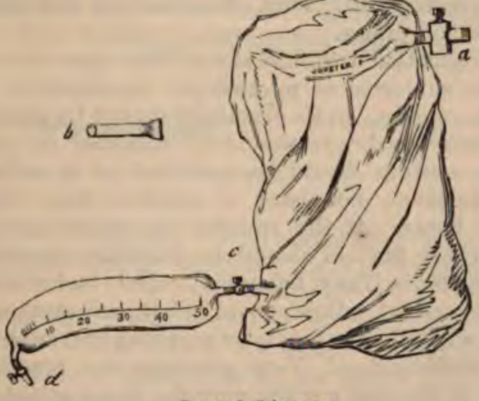
The employment of this instrument is surrounded with difficulties, so far as its results are to be regarded as tests of the presence of phthisis at least. A patient brought for the first time to this instrument is seldom able to make a proper use of it. He is generally nervous, and commences blowing by making a very short expiration. He inspires, expires again, and if not stopped, will go on in this way till he has forced the small cylinder up as far as it will go, employing for this result some half-dozen expirations. It is well for him to look at it, to become familiar with it, and to see others rightly make use of it, before he himself tries it. In short, he requires education to employ it, and coolness and self-possession. When, like the horse in its harness, which has become steady, the composed patient may now proceed with the trial. With his chest freed from all external restraint, he is to make a deliberate and forced inspiration; and, having the tube ready, he is to place the extremity in his mouth, and endeavour to breathe out all the air which his chest contains. When this is done, and before his mouth is removed from the tube, a tap which had been turned to permit of the ingress of air into the cylinder is to be now turned off, to prevent its egress, until the amount of air in the cylinder is ascertained by reference to the index.

Nervous patients seldom succeed with this instrument until they have made several trials. Young females are difficult to manage for observations of this kind. Some persons never succeed in making a sufficiently full inspiration, and the necessary prolonged expiratory act.

Loss of real capacity is not the only cause of a small amount of expiration air. The patient may be feeble, or he may have pain, and be thus unfit for the continuous effort of a forced expiration. This instrument tells us nothing of the part of the chest that is deficient in capacity. What air is expired comes always from the air passages in part, and sometimes from the pleural cavity.

Dr. Hutchinson's spirometer is so generally known that a figure of it is unnecessary here.

Dr. Pereira's spirometer.—This appears to be much the same instrument as Hutchinson's. Instead of a smaller cylinder of metal, as in Hutchinson's spirometer, we have a glass one. This is suspended in a larger vessel filled with water. Water also fills or nearly fills the glass cylinder. A tube conducts the expired air into the glass cylinder. As the air enters the glass rises, as the small cylinder does in Hutchinson's instrument.



Coxeter's Spirometer.

a Stop-cock for inflation. *b* Mouth-piece to fit upon *a*. *c* Stop-cock between reservoir and meter.

Mr. Coxeter's spirometer.—This instrument differs from Mr. Hutchinson's spirometer in principle, and possesses the advantages of equal accuracy, greater portability, and comparative cheapness. It consists of two bags, one acting as a reservoir for expired air, and the other as a measure. The air is first expired into the larger bag supplied with stop cocks to retain it. The next step is to pass seriatim the air into the measure bag, and to calculate the amount. The second bag can contain forty or fifty cubic inches, and it is to be filled from time to time, till the whole amount is measured. This instrument costs only 26s., and Mr. Coxeter, I understand, has very recently improved it.

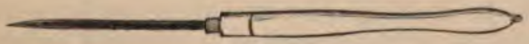
In a work devoted to the physical exploration of pulmonary consumption, it may be permitted to me to say a word respecting the microscope.

THE MICROSCOPE.—For the purpose of examining the sputum, and for detecting the presence of tubercle and of pulmonary curly fibre, the microscope is most important. The detection of tubercle corpuscles and of commingled curly fibres, by the microscope, gives certainty as to the presence of pulmonary disease. Even in advanced cases of phthisis, those in the second and third stages, this piece of evidence is often most corroborating, and of great value. In the first stage, and the transition period between the first and second, the discovery of tubercle, &c., gives a significance to doubtful symptoms and ill-developed signs.

Not a word need be said upon the construction or the mode of using this instrument. That office has been well performed by Dr. Beale and others.

But it is right that I should say a little upon the sputum that is to be subjected to microscopic examination. In the first place the sputum to be examined should be preserved in a *well*-cleaned vessel. It should be collected in pure cold water. The sputum should be examined at an early period after expectoration, not later if possible than twelve or twenty-four hours. If the sputum be scanty and frothy, parts from every portion should be carefully examined, the more opaque points, if any, being particularly looked to. If the sputum be abundant, adhesive and gelatinous, we should look for opaque, whitish firm points or particles, and subject them to careful examination. Very generally the practised eye will be able to discover a white particle, like a minute crumb of cheese, in a great mass of sputum. This will generally be found when broken down and mixed with a little water, to present the microscopic tubercle corpuscle, and the curly fibre. There may be tubercle corpuscle without curly fibre. The corpuscle of tubercle is generally of much the same form in the same individual, but it varies much in shape, in size, and in outline and definition, in different persons. I have not found curly fibre without tubercle, except in cases conjoined with gangrene.

EXPLORING NEEDLE.—A needle is occasionally of use in the exploration of the chest suspected to suffer from one of the consequences of pulmonary consumption, viz., serous or sero-purulent effusion in the cavity of the pleura. It occasionally, though rarely, happens that in the three first stages of this disease effusion takes place, and that it may be deemed advisable to puncture for its removal. In the fourth stage effusion is very common, and though this operation is little likely to be of use, still some examples may occur in which the propriety of the step may be entertained. Before proceeding to actual tapping, it is well in most cases at least to explore with the needle, and positively discover the presence of liquid. By doing this considerable advantages are obtained. If no liquid issues we are warned not to operate, and we thus avoid a very mortifying disappointment, and we do not endanger the life of the patient. If liquid issues with the needle, the operation may be proceeded with in comfort. That such exploratory efforts are not altogether supererogatory, appears from the fact that tapping, or rather penetration, of the thorax, even under the direction of good physicians, has been performed, when no liquid has been present. The needle, including the handle, is about three inches and a half long. The needle is grooved, so as to admit of liquid flowing alongside, when it has penetrated the chest.



The Needle.

The breadth of the needle at its broadest part is only about the twentieth part of an inch. The aperture made by this needle is so small, that no air passes into the cavity of the pleura when it is in the walls of the thorax or when it is removed. No evil ever results from this exploratory measure, and the advantages are not insignificant which accrue from its precautionary adoption.

The best locality for the penetration of the exploring needle in ordinary cases is the fifth interspace in the lower lateral region.

The mode of procedure is this. The skin is rendered tense by the thumb and forefinger of the left hand; the needle held by its handle between the thumb, fore and middle fingers of the right hand, is pushed gently and gradually into the thorax, a little above the upper edge of the rib. When the needle-point has cleared the pleura it will be felt to move jerkingly onwards. The needle may now be moved a little further, say one line more. If there be any liquid in the cavity of the pleura, a little liquor will be found to issue from the grooved surface of the needle. This occurrence now declares for proceeding to the employment of the trochar.

CHAP. XLV.

The Examination of the Mouth, Fauces, Larynx, &c.—Tongue Depressors.—Specula.—Illuminated Specula.—Avery's Speculum.—Czermack's Laryngoscope.—Table of Thoracic Regions.

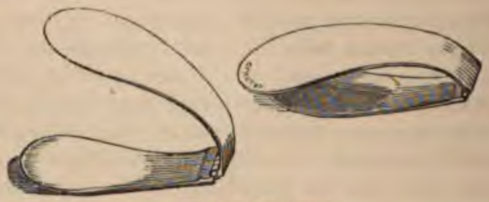
THE EXAMINATION OF THE MOUTH, FAUCES, LARYNX, ETC.—This is a very important office. It is one which should never be omitted, if it can be at all conveniently done. The state of the gums, the tongue, fauces, and other parts will greatly assist us in deciding upon the nature and extent of the disease of the patient, as well as in obtaining indications for the treatment.

If, when the patient is only slightly disturbed in his health, and when the thoracic physical signs of phthisis are ill marked, the gums present a fine red border along the edge of union with the teeth, and the fauces are only very slightly congested, or perfectly healthy, the probability of pulmonary disease in an incipient form being the primary complaint is considerable. If, on the other hand, the fauces be highly vascular, granular or granulous, the posterior wall of the pharynx be rough, tuberculated, and covered here and there with thick green mucus, or the tonsils be irritable, large, and projecting, and associated with enlarged cervical glands on the exterior of the neck, and the voice be more or less hoarse or nasal, and no decisive physical signs of phthisis are to be obtained by auscultation or percussion, it is highly probable that the primary and chief disease is within sight, and that the thoracic symptoms and signs are only secondary, and very likely to pass off upon the cure of the morbid conditions above referred to.

When the mouth of the patient is to be examined, if in bed, he should be made to sit up. If out of bed, he may stand or sit down, but care should be taken that he is placed before a window or nearly in front of a good light. The physician must endeavour to place his head on a level with that of the patient and move the head of the examinee so that the innermost parts of the pharynx may be brought into view. The sitting posture with the head gently thrown back is very suitable for examining the pharnyx. To have a good view of the interior of the mouth, and to allow of the admission of sufficient light, it is a good plan—though perhaps a somewhat coarse one—to introduce the forefinger of the two hands into the mouth respectively at the two angles, and separate the angles to a convenient distance. This can only be done of course when the hands are not engaged with instruments, or in the management of artificial light.

THE MANAGEMENT OF THE TONGUE.—The behaviour of the tongue of the patient is an important point. Some persons have the happy art of keeping this member easily, and for a considerable period, deep down in the floor of the mouth, thus greatly facilitating ocular inspection. Others, on the other hand, have such a rebellious and obstinate member, that no exertion of the owner and no direction on the part of the physician will succeed in preventing it rising, in the most sight-obscuring manner, between the eye of the observer and the fauces of the patient. If ducked down for a moment, it will rise the next and be proof against any exertion. For such persons various means have been employed, and some instruments have been contrived. The tongue is conveniently and very readily depressed by the forefinger of the physician, but some practitioners would be afraid to risk their reputation for delicacy by adopting this method; and again, some squeamish patients may have a repugnance to it. Yet it has its advantages; the examination is made at once before the spatula and depressor could be introduced, and this is no slight matter when we have to deal with hysterical men or women, and with spoiled naughty children. The latter may possibly complain or cry, but the examination *has* been already made, and this is satisfactory. When employing the finger we must guard against being bitten.

TONGUE DEPRESSORS.—Instruments so called are in general use, and should be in the possession of every physician called upon to treat much disease of the chest and throat. A very convenient form of depressor is one shaped like the handle of a table-spoon. It is about five inches long. The widest part is about an inch in width. The surface which comes in contact with the tongue is gently concave, *so as* in part to receive the tongue and thus keep it under. Children require a smaller instrument. To use this depressor the physician takes it in his right hand, and standing or sitting a little to the right of the patient, gently introduces it till the extremity has reached the root of the tongue: he now depresses that organ and keeps it firmly out of the range of vision. A common non-flexible metal or wooden spatula, or even a strong ivory paper-knife, form convenient substitutes. When it is necessary to keep the tongue out of the way some considerable time, or when we have to deal with restless patients, another form of depressor is useful. Connected with the depressing part of the instrument, we have an arm which descends at right angles, and comes in contact with the chin, which forms a convenient *point d'appui;* and the danger of passing the instrument too far is avoided. A movable joint connects the two parts so that the instrument may be extended or bent, or folded at pleasure.

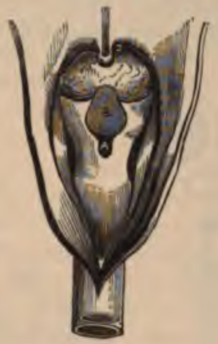


Tongue Depressors.

By means of the instruments just described, and a good light, a fair view may generally be obtained of the pharynx, tonsils, and even of the epiglottis.

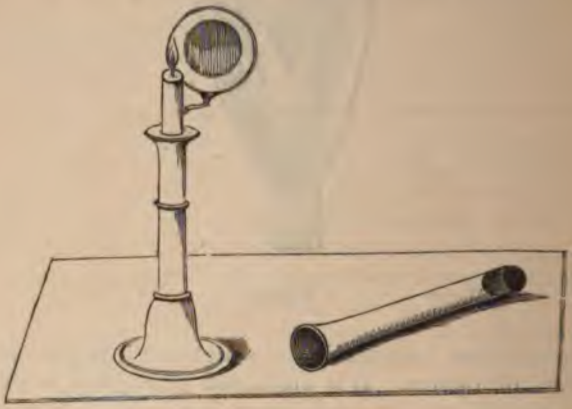
The epiglottis is even occasionally brought into view simply by the efforts of the patient, without any aid from the physician. But it frequently happens that the means indicated above do not succeed in enabling the explorer to see the epiglottis and the rima; it is therefore necessary to employ others.

Specula have been, of recent years, rather largely employed to bring the epiglottis and the rima glottidis into view. A mirror of glass or metal is introduced into the mouth and held so as to reflect an image of the parts upon the retina of the observer. The usual mirror is about half an inch square and is gently bent upon the handle. Liston recommended such an instrument years ago. To employ this instrument, it is warmed before introduction into the mouth, to prevent condensation of vapour. It is employed gently and brought as little in contact with the patient as is possible. It is moved about until the image is brought into vision. It may be allowed to touch the soft palate and uvula, but it is desirable to avoid contact with the tongue and pharynx. If it touch the latter part, involuntary acts of deglutition take place. To the use of the speculum has been latterly added the advantages of illumination. A metallic reflector has been added to it, by which the interior of the mouth and the larynx have been lighted up. Mr. Avery, I believe, was the first to make use of this instrument. While a speculum consisting of a metal cylinder with a mirror at its further extremity is held in the mouth, the light of a candle lamp is received upon a concave reflector connected with this lamp and made to enter the mouth, through the cylinder, the explorer looking through the speculum in the mouth over the edge of the reflector. This is a very useful instrument, the glottis and the larynx are well seen with it, and it is easily managed. When a good inspection is desired, this instrument may be employed. It is to be borne in mind that, simple as it is, and capable of quick adjustment, it is occasionally found to be irksome to the patient, and it sometimes happens that contact of the speculum with the soft palate, &c., of the patient brings on spasmodic movements which render it necessary to desist



A. Glottis. B. Epiglottis. C. Uvula.

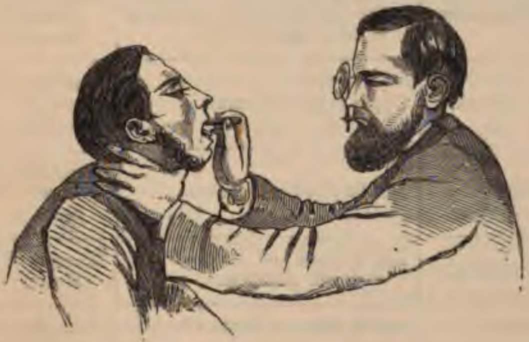
from its employment. The patient is to be seated before the examiner. The latter holds the lamp and reflector in one hand, while he holds the speculum in the mouth of the patient with the other. The mirror in the mouth is to be held above the rima when the larynx is to be inspected. The subjoined figures represent a speculum having a mirror at the smaller extremity, and a candle lamp furnished with a reflector.



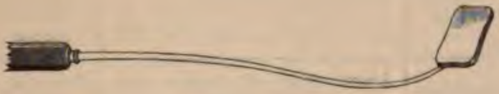
The Speculum after Avery.

Within the last few months the ingenious contrivances of Czermack and Dr. Türck of Vienna for inspecting the larynx have been brought before the profession in England, and have excited much interest. The chief improvement over the lamp and speculum above described, and which has been in use in England for some years, consists in an arrangement in respect of the reflector, by means of which the examiner looks *through* instead of *over* the reflector. The reflector which is concave, is perforated in the middle, and the eye of the physician inspects through it. This reflector receives its light either from the sun or from a lamp or gas-burner with which may be connected a bi-convex lens. The reflector is held before the eye by the teeth or by means of a common spectacle-frame. The speculum or mirror used by these physicians, is fixed to a flexible metal handle, about four inches long. It is held so as to illuminate the parts, and to reflect an image of them into the eye, through the perforation in the concave reflector. The interior of the larynx, and (it is said) the interior of the trachea down to its bifurcation, are to be thus successfully explored.

By changing the direction of the speculum, the posterior nares and pharynx may be also examined. This apparatus is called the laryngoscope. It is a valuable addition to our means of physical exploration, and its successful employment is not to be despaired of, because a first or a second trial may happen to disappoint the expectations of the physician. Practice may at length make him a Czermack or a Türck. The subjoined woodcuts represent the speculum and the perforated concave reflector. The mode of employing them is also exhibited.



The Laryngoscope in use.



The Speculum.

The division of the chest into regions is of great practical importance. A table of regions is to be found in the following page. The sternal regions are strictly confined to the sternum and ensiform cartilage; and the lateral regions are bounded by lines drawn perpendicularly from the anterior and posterior borders of the axilla.

THORACIC REGIONS.

Names.	Situation.	Corresponding Organs.
1. Supra-clavicular.	Above clavicle.	Summit of lungs.
2. Clavicular.	Clavicle.	Summit of lungs.
3. Infra-clavicular.	Between clavicle and lower edge of third rib.	Upper lobe of lung: large bronchi.
4. Mammary.	Between lower edge of third rib and seventh rib.	Middle lobe: large bronchi. Heart on left.
5. Infra-mammary.	Between the seventh rib and the border of the cartilages of false ribs.	Liver on right. Stomach on left. Margins of lungs.
6. Upper sternal.	Upper third of sternum.	Trachea and large bronchi. Great vessels.
7. Mid-sternal.	Middle third of sternum.	Margins of middle lobes. Base of heart.
8. Lower sternal.	Lower third of sternum and ensiform cartilage.	Margins of lungs. Heart.
9. Axillary.	Axilla down to fourth rib.	Side of apex of lung.
10. Lateral.	Between fourth and seventh rib, laterally.	Lateral aspect of lungs.
11. Inferior lateral.	Below the seventh rib.	Lateral aspect of lungs inferiorly. Liver on right. Stomach and spleen on left.
12. Supra-scapular.	Above spine of scapula and third dorsal vertebra.	Posterior aspect of apex.
13. Scapular.	The scapula below spine.	Middle and posterior parts of lung.
14. Inter-scapular.	Between inner margin of scapula and the vertebræ.	Roots of lung.
15. Inferior dorsal.	Below angle of scapula to level of twelfth dorsal vertebra, posteriorly.	Base of the lung. Liver inferiorly on right. Stomach and intestines on left.

NOTE.—This Table has been adopted, in great measure, from the work of Dr. Williams on Diseases of the Chest.

PART III.

ON MEASURING THE CONFIGURATION OF THE CHEST IN DISEASE.

[*From Dr. Beale's "Archives of Medicine," No. II.* 1858.]

The mensuration of the thorax affords much aid in the diagnosis of the diseases of that portion of the body, and materially assists us in deciding whether a morbid condition there located be increasing or in process of abatement. The information which mensuration procures is remarkable for that precision and certainty which mark the data of physical science. In this respect it greatly surpasses in value that large portion of medical evidence called symptoms, on which medical diagnosis and prognosis are greatly founded, for these being in a great measure simply the sensations of the patient, may vary from hour to hour, although the important fundamental pathological conditions of organs may remain the same; and because the language, which is their exponent, is less fixed and precise than the symbols of physical science, and is often, in degree at least, determined by the temperament or even the varying temper of the patient. This contrast, drawn in favour of mensuration, is not intended to depreciate the importance of symptomology, without which testimony, most valuable in itself, would be lost, and cues for the application of physical tests themselves could not be obtained.

The mensuration of the chest, by which is meant that measurement which is effected by physical appliances, was, until lately, accomplished almost exclusively by the application of the tape measure. To determine the circumference of the chest it is passed round the part; but as it is the comparison of one side with another that is chiefly desiderated, the tape is applied in almost all cases to compare the semi-circumference of the one side with the semi-circumference of the other, and this is done by placing the end of the tape on a spinous process and carrying the measure round to a point at the middle of the sternum. This done on one side and then on another, the difference in the two measures gives the difference of the two sides. By means of this mode of measurement, we obtain the dimensions of the entire halves of the thorax, but it fails to determine any particular part where the increase or diminution of dimension in a half of the chest, may be present; thus, the semi-circumference so taken would not inform us, in a case of protuberance of the præcordial region from great hypertrophy of the heart, that the excess in the measurement was due to fulness of the præcordial region, it would simply notify an excess in the general dimension of the side. It is true that, for the measurement of a part of the thorax, the tape is employed; thus the distance from the nearest part of the sternum to the nipple, and the distance from the sterno-clavicular articulation to the nipple, are ascertained by the tape; but we find that a material increase of size and deviation from the natural configuration may be present, which can with difficulty be represented by this measure. Thus a præcordial fulness, perfectly obvious to the eye, frequently fails to pronounce itself in a decided manner by the tape thus topically applied.

The distance of one part of the thorax from another, including the cavity between them, has been ascertained by means of callipers, and this instrument has afforded some valuable information, not obtainable by the tape. This instrument gives that information respecting the magnitude of a part of the half thorax which is not obtained by the tape; thus, where a deficiency is found on the right side, from consolidation of the front of the middle lobe, this may give rise only to a flattening of the third or fourth ribs in front, the callipers will declare this, while the tape will not detect it. The callipers have been recently improved for the purposes of thoracic mensuration by Dr. Edwards, who has added to it a delicate and useful graduated scale.

Perhaps it may be permitted to say a word or two respecting some other mechanical contrivances employed in the diagnosis of thoracic disease. The elevation of the ribs in inspiration is measured by the stethometer of Dr. Sibson; during the elevation of the chest the instrument is carried forward, and the degree of its movement is indicated by a scale which is connected with the part resting on the chest. This instrument requires to be fixed at one end, and this is generally effected by supporting the arm on the back of a chair. Dr. Quain is the inventor of another instrument for measuring the elevation or expansion of the chest. It is more portable, and better fitted for the examination of different parts of the chest, and is more delicate than Dr. Sibson's. It consists of a thread, which is placed across the part to be measured, one end of which is fastened on the chest with the finger, while the other is connected with a spring which moves a handle on a dial duly graduated. The slightest expansion of that part of the chest under the thread moves the spring, and this movement again indicates itself upon the dial.

The sphygmoscope which the author invented to denote the pulsations of the heart, is capable, when slightly modified, of proving a good measurer of the movements of the chest. When so used it is placed upon a fixed stand, and is then called a pneumatoscope. It consists of a small projecting bag of water, which is placed upon the chest, and has connected with it a graduated scale. The elevation of the chest in inspiration, as well as the fall in expiration, are delicately measured by it; by no other means can the absolute and the relative duration of these acts be so delicately measured.

The ingenious and interesting instrument, the spirometer, invented by Dr. Hutchinson, measures the quantity of air expired from the thorax; but while it serves to indicate the total capacity of the chest for air, or for the vital capacity, as it is incorrectly called, it is utterly null, as an index of the capacity of any particular part of the breathing apparatus.

The instruments above referred to measure magnitudes, movements, and capacity, but deviations from the natural configuration of the thorax present themselves, which do not come under the description of magnitudes, movements, or capacity, and which cannot be measured by any of the means above enumerated. The deviations not so included are of very frequent occurrence, many of them are observed at any early period of disease of the contained organs, and may be made subservient as elements in diagnosis, whether other evidence be more or less complete.

The deviations here referred to relate to the angles and curves formed by the bones composing the chest; by the junction of one bone with another part, and of bones with cartilages. Angles may replace curves, and curves may so alter as to belong to greater or smaller circles or radii than natural. Such deviations from the natural configuration being not at all or very imperfectly gauged by the appliances already described, the goniometer or stetho-goniometer has been introduced for their measurement as an instrument of diagnosis, &c., in diseases of the chest.

The chief deviations for the measurement of which the stetho-goniometer is adapted, occur at the upper and front part of the thorax, at the junction of the costal cartilages with the sternum, and at the junction of the costal cartilages with the ribs. But departures from the healthy configuration are of very frequent occurrence at almost all parts of the thorax. Deviations hold in respect of portions of the sternum in relation to each other, or in respect of the entire bone in reference to the spine, the ribs, or of the mesial or transverse lines. The natural curve of the entire sternum may be an unnatural deviation. The costal cartilages may incline in an abnormal manner to the sternum, the natural curve of the costal cartilages may be replaced by some unusual form, either angular or curved. The ribs and costal cartilages may incline to each other in preternatural planes, and the dorsal spine may present abnormal curves. Deviations from the natural configuration of the dorsal spine may be regarded and measured either by themselves or in reference to the plane of the sternum, the mesial plane of the body or the horizontal line. All such deviations may be readily measured by the stetho-goniometer. When deviations are confined to one side of the body only, the instrument may be made to measure the difference between the two sides, the healthy and unhealthy, by applying it successively to the corresponding parts.

A few words on the natural configuration of the thorax. The male adult is spoken of, except when it is otherwise mentioned.

The thoracic bones form a long case of a conical configuration, flattened in front and behind, having its longest diameter from above downwards. The diameter from side to side exceeds that from front to back, being about double; the greatest lateral diameter is found on a level with the eighth rib, at the lateral region; this is more than double its diameter at the level of the first rib.

The dorsal spine is placed in the mesial line, and describes a gentle curve, the convexity of which is behind, and the concavity in front. In the erect position a plumb-line would very nearly fall upon the upper and the lower extremities of the curve. The two arms of the stetho-goniometer placed respectively upon two equal divisions of this curve, becoming tangents to the curve, show an angle at their junction, for the most part about 170° in men, and about 160° in females, the back in the latter being more curved than in men: hence proceeds so much of the beauty of the feminine form, with its rounded outline, so conspicuous in "the bending statue which enchants the world."

The sternum placed in the mesial line, in front, describes a curve from above downwards, the convexity of which is turned outwards. The tangents of this curve measured by the arms of the stetho-goniometer indicate in most persons an angle of 175°. The sternum separates more and more from the spine as it descends, and is directed forward. The inclination forward is described by saying that the sternum forms with a plumb line touching its lowest point, an angle of about 165°. The outer surface of the sternum from its superior part to the attachment of the fourth rib, is wholly plane, below the latter part it shows a slight concavity. The outer surface, from right to left, is strictly in health, in the transverse plane of the body; all deviations are unnatural.

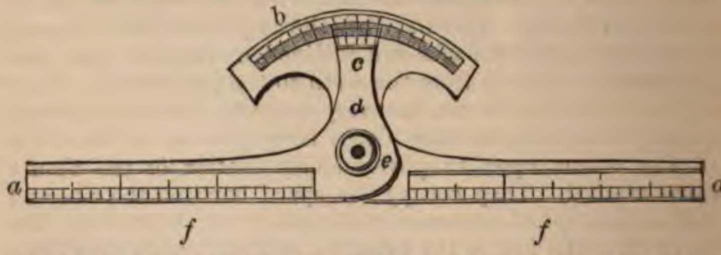
The ribs of either side form a rude semi-circle. The circle described by the front part of the first seven ribs, is larger than that described by the posterior part. The circle described by the outer portion is much smaller than either of the others. The arms of the stetho-goniometer placed upon the front, and used as tangents, so to speak, indicate an angle of about 160°; and upon the lateral regions below the axilla an angle of 150°. The first rib is the only one which is nearly horizontal. All the ribs are inclined downwards, and this inclination increases from the sixth to the twelfth rib.

The costal cartilages, are very important in this investigation, occupying, as they do, a large portion of the front of the thorax open to physical examination of the nature here treated. They occupy the space between the ribs and the sternum, and increase in length from the first to the seventh. The first is the broadest, and descends a very little in its course from the rib to the sternum. This cartilage, in its descent, forms, with the transverse plane of the body, an angle of 177° or 178°. The second cartilage is horizontal, the third ascends a little, and with a horizontal or transverse line forms an angle of 183°. The fourth and fifth costal cartilages incline very considerably upwards. The upper cartilages present a slight convexity on their outer surface, the curves of which are of much the same degree. Measured by the stetho-goniometer, the curve may be said to be about 165°. The length of the first cartilage is about an inch, and each cartilage, as we descend, gains about half an inch. The upper portion of the front of the chest, including the sternum and the cartilages on both sides in front, describe a curve of pretty uniform configuration, which, measured by the stetho-goniometer, is about 165°.

During inspiration, the sternum and costal cartilages are elevated. The latter parts have their curves increased, the lateral parts of the ribs are elevated, and the lower eight are forced somewhat outwards. The distance of the sternum at its upper extremity from the opposite vertebræ is about 2½ inches, its lower extremity from the opposite vertebræ, is 6 inches. The distance from the eighth rib of one side to the eighth rib of the other, is 10 inches.

In females the ribs describe curves of smaller radius than in men; and the younger the chest is, its curves are of comparatively smaller radius.

In health, few straight lines or angles are to be observed in the outline of the thorax, but the case is different in disease, for in phthisis and other maladies straight lines and angles are frequently found. These, of course, admit of ready measurement by means of the stetho-goniometer. But the deviation from health in many instances consists in an alteration of the natural curve rather than in the replacement of a curve by a straight line or an angular development. Though the goniometer cannot pretend to measure curves with the same accuracy as angles, it will practically prove as useful in the one case as in the other, for the approximation to the truth will be so near as to be in practice equivalent to it. The absence of great mathematical nicety will not interfere with the useful revelations of the instrument. To measure curves has always been an acknowledged difficulty, but with the arms of the stetho-goniometer, employed to measure the angle of tangents to curves, on which they are placed, a highly useful approximative measure will be obtained.



Stetho-goniometer, for measuring the inclination of different parts of the walls of the thorax in cases of disease.

a a. The arms. *b.* The arc of a circle, graduated from 120° to 220°, the latter degree being on the left hand. *c.* The vernier, with an arrow at zero; the index of degrees. The vernier is divided into 12 equal parts, the whole being equivalent to 1° on the arc, or to 60′. *d.* Vernier arm. *e.* Joint. *f.* Inches and 10ths of inches, marked by lines, which when brought into line by bringing the two arms nearly together, would determine the 1st degree, if instead of an arc it had an entire circle.

The word stetho-goniometer is composed of three Greek words signifying chest, angle, and measure. It is of much the same construction as the goniometer employed in the examination of crystals. The stetho-goniometer, as already stated, is intended to measure the angles at which the planes of different parts of the thorax are inclined to each other, and to determine tangentially the comparative configuration of curved surfaces. It is formed of two arms, each three inches long, jointed together, and connected with them are an arc, divided into degrees, and a vernier.

The edge of the arms are to be placed upon the chest. When both arms rest upon the same plane, the vernier points to 180°, the angle represented, if I may so speak, by a flat surface or a straight line, the condition in fact of the instrument in this state.

The degrees commence when the lines on the arms may be seen in line, and the circle is completed when the arms, having revolved, present their lines again in line. When the arms have completed less than half a revolution, the vernier points to angles under 180°; when they have completed more than half, the vernier points to angles greater than 180°. The angles of the chest to be measured by the stetho-goniometer, range almost exclusively from 120° to 220°; an arc, therefore, has been adopted which includes these degrees only. It comprises the plane and degrees on either side. This range will generally be found sufficient, but for a more extended inquiry a longer arc or the entire circle may be employed. The arrow on the vernier arm marks the degree.

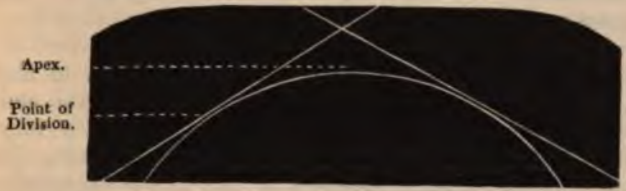
When great nicety is desired and minutes are required, which will seldom be the case, the vernier may be employed. This, in the stetho-goniometer, subdivides the degree into twelve equal parts. These twelve parts correspond exactly with one division on the arc. Each division therefore on the vernier is smaller than the division on the arc by the 12th part of a degree. Thus, each division on the vernier represents 5′ (minutes), and as there are twelve, the vernier corresponds with 60′ (minutes) or 1° (degree). When a degree without any minutes is indicated, the star or zero of the vernier is in a line with a line of the arc. If the star point to a degree and a little more, and we desire to know how much this is in minutes, we look along the vernier for that line which coincides or is in a line with a line on the arc. If we are reading angles *up* the scale, ascending, we count from the right hand, and multiplying each line by five, we determine the number of minutes. If we are reading down the scale—say, measuring an angle of less than 160°—

we look for the line on the vernier corresponding with a line on the arc, and, counting from the left hand, we multiply by five, and determine the number of minutes. The vernier will seldom be required in stetho-goniometry, yet an acquaintance with it is not undesirable.

The arms of the stetho-goniometer are divided into inches. When the instrument is employed to measure an angle formed by the vertical line and another line, one arm is placed in the perpendicular, and this is done entirely by the guidance of a plumb-line, or of some line or body corresponding with it. When the horizontal line is required for one arm of the instrument, it is guided by a body occupying that position, and placing the two in a horizontal position. When great nicety is required, a level may be employed to give the horizontal line. The measurement of angular parts is very easy; the point of junction of the two arms of the instrument is placed over the point of junction of the two planes to be measured, and the two arms are respectively applied to the two planes; the degree indicated by the arms is the angle of the inclination of the two planes. To measure the depression of the clavicle or of the ribs from the horizontal line, we place one arm in the plane of the horizon, and another in the plane of the clavicle or rib, and read off the degree indicated by the arrow. If we desire to know the extent of the projection of the sternum, we place one arm, say the lower, in the vertical line, and lay the other upon the sternum in its long direction or axis.

The angular measurements are thus made by the examination of two real planes of the body, or by the examination of one plane of the body with fixed standards, the vertical and the horizontal or transverse lines. In some cases, the measurement of the two planes of the body will suffice in the examination of the patient, as when a costal cartilage suddenly retires from the sternum, which still maintains its normal plane, but where the flattening or receding involves the sternum, which is frequently the case in phthisis with large old cavities, or in great condensation of the lung, this measurement is not sufficient, and it is necessary to take the angle formed by the transverse plane of the sternum with the transverse plane of the body. A great abnormal deviation may be now exhibited, not to be appreciated by the former measurement only. The point of junction of two parts of a bone, or of two bones, may not be strictly angular, being somewhat rounded or curved, yet when the curvature is not considerable, and the two parts as they separate, obviously describe an angle, the junction may be practically treated as an angular one.

Many deviations from the natural form of the chest cannot possibly be regarded as angular, and are essentially curves or portions of circles; it is desirable to measure them both for recording and for comparison with sound parts. This may be done with the stetho-goniometer in this manner: we fix upon the apex or middle of the curve, and upon a point which divides the portion of a curve which is on either side of the apex, into two equal parts; we then bring the arms of the instrument to form tangents to the curves at these points, the joint part of the instrument being held above the apex. The degree on the arc pointed at by the vernier, will be an accurate indication of the configuration of the curve. To compare one curve with another—say, a natural with a preternatural one—the arcs to be measured must be of the same length. The larger the circle of which the curve is a segment, the greater is the angle of the tangents. It will be found that the stetho-goniometer so employed, will practically afford not only a good measure of the angle of the tangents to the curve at their bisection, but will give a fair rough outline of the curve itself.



Depressions, whether angular or curved, may be measured with the stetho-goniometer. When angular, the instrument at its point of junction is applied to the point of union of the two lines of the body, and the arms laid upon the retiring planes respectively. In the case of a curved hollow, less exactitude is procurable, but a fair rough measure is obtainable, which is valuable for comparison and record, and even a tolerably exact outline is placed at our command. The centre point of the instrument is placed near the lowest part of the hollow, and, as it were, opposite to the apex, and the arms are held, on either side parallel with two tangential lines. Hollows of smaller radius are represented on the stetho-goniometer by the complement of the angles shown on the goniometer. The arms in the first case, approach each other more, or more nearly complete the entire revolution of the circles; and, therefore, indicate a higher degree. Such depressions, both curved and angular, are frequently seen in diseases of the thoracic organs, and I may here state that lately I found the sternum to be the depressed angular point of meeting of the clavicles, in a case of phthisis marked by great depression of the middle of the chest, and of projection of the shoulders. In this case, instead of having a curve of 170°, there *was an angle* of 195°.

The stetho-goniometer, constructed by Mr. Adie, of the Strand, is made of ivory, weighs less than half an ounce, and is therefore very portable. Its employment occupies very little time, and is in no way disagreeable to the patient. It is simply requisite to uncover the chest but this is essentially necessary in any examination that would pretend to accuracy or completeness.

The following figures will illustrate the mode of application:

Plate XI., fig. 1 (see Frontispiece), represents the chest of a girl fourteen years old, afflicted with pulmonary consumption. The left lung is the seat of a cavity, and of much contraction of the remaining pulmonary structure, probably due to the presence of much fibrous exudation in the structure itself, and upon its pleural surface. The left side of the chest has undergone great retraction, very obvious to the eye. The sternum has deviated from the transverse plane of the body, and forms with it an angle of 170°. The transverse plane of the sternum forms a straight line with the first three costal cartilages. The left clavicle has declined at an angle of 175° with the horizontal line, while the other clavicle rises and forms an angle of 185° with the horizontal line. The goniometer is placed on the left side, the joint resting upon the right border of the sternum; the right arm is placed upon the sternum and the second costal cartilage, while the right arm is maintained in the transverse line of the body. The index points to 170°. The heart has been dragged upwards, and the auricle is felt pulsating at the second left interspace synchronously with the apex in the fourth interspace. Great as is the retraction in this case, marked not only at the part on which the instrument is applied, but by remarkable flattening on the whole left front, delicately indicated by the goniometer, the total loss on the whole semi-circumference of the thorax, as measured by the tape measure, is only half an inch. This figure indicates a deviation from the natural relation of the transverse plane of the sternum to the transverse line of the body. This patient is now in the Hospital, under Dr. Cursham.

Fig. 2 (see Frontispiece) represents a lateral curve of the spine in a case of phthisis, under the same circumstances. The arms of the goniometer are made to occupy the place of the tangents to the curve of the spine. The angle at which these tangents bisect each other is one of 168°. The convexity looks to the diseased side.

Fig. 3 (see Frontispiece) represents the chest of a youth suffering from very great hypertrophy of the heart, with deficiency of semilunar and mitral valves, causing loss of symmetry in front of the thorax. The left mammary and inframammary regions are very full; the curves of small circles are replaced by curves of much larger circles, by which a flattened, though, at the same time, a greatly fuller aspect is conferred. The stetho-goniometer is placed upon the left* region in a vertical direction, and it will be observed that the arms of the instrument tend to form one straight line. The arms of the instrument are made to occupy the place of tangents to the curve, and the angle made by the bisection is one of 164°. The angle of tangents to the curve on the corresponding part of the other side of the chest is one of 150°. The instrument is represented on either side of the chest.

It is believed that enough has now been said to indicate the objects of the stetho-goniometer, and to illustrate its application in the measurement of the angles and curves of the chest. A very little practice with the instrument will make it available in the hands of the student. It will probably be found to afford, as already said, data not to be obtained by other means. It will give a definite symbol of phenomena, which cannot be misunderstood, which admits of accurate record for purposes of future comparison and accurate communication to others present or at a distance. The author believes it will assist in the diagnosis of disease in its early as well as in its later stages. By leading to a close examination of the chest, facts otherwise likely to escape notice will be discovered, and by fostering habits of diligent and precise observation, cannot fail to be of use to the student as well as ultimately to the sick who are to come under his care. While it is capable of supplying facts not obtainable by other mechanical contrivances, its revelations will often be found to derive confirmation and important qualification from them, so that, in bringing the stetho-goniometer before the profession, it is far from the author's intention to depreciate other means of determining the state and conformation of the thorax.

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* Drawings 1 and 3 have unfortunately been reversed, so that the left side in the drawing is really the right side of the patient.

In the next part of this communication, it is proposed to give the history of some of the more important deviations from the natural configuration of the thorax measurable by the stetho-goniometer, which are found to arise from maladies of the contained viscera and investing membrane, and which the author has seen in a very large proportion of the patients, including many in the first stage of pulmonary consumption, who have come under his care at the Brompton Hospital.

ON THE CHANGE OF FORM IN THE CHEST IN CASES OF DISEASE.

[*From Dr. Beale's Archives of Medicine, No. III.* 1858.]

In the last number of the "Archives of Medicine," some observations were made upon the means usually employed in the mensuration of the thorax. The form of the healthy chest was considered. An instrument, the stetho-goniometer, which the author has employed in measuring the curves and angles of that region was described, and the advantages it possesses and the mode of using it were pointed out. It now remains to describe some of those deviations from the natural form of the chest which the stetho-goniometer is able to detect and measure as well for future comparison as for present consideration.

In doing this, the history of those deviations only which proceed from disease of the internal soft parts will be given. But it is right to observe that deviations from the normal form arising from disease of the thoracic bones themselves from spinal curvature, or from occupation or posture, are equally well measured by this instrument.

The deviations now to be considered will be found to relate to pulmonary consumption in an especial manner. The author's observation of such deviations has been extensive from his connection with the Brompton Hospital, and a knowledge of them will naturally be interesting and valuable from the great frequency of this disease.

The departure from the healthy form occurs at an early period of the progress of pulmonary consumption, and will in many cases where there is a deficiency of acoustic signs, prove, as it has often done to the author, an aid of some value and deserving of some reliance; while the departure of the early stage becomes as the disease progresses a striking and remarkable deformity, testifying to the wonderful modelling powers of morbid soft structure even upon hard osseous and cartilaginous parts, and, as will be seen at a later period of this communication, not only assisting in diagnosis but actually subserving the process of reparation and of cure.

Bayle long ago pointed out that in chronic phthisis the chest became retracted. M. Laennec described the retraction of the ribs when the walls of large abscesses and tuberculous cavities contracted. The fulness and roundness in empyema, with the alteration of the transverse plane of the ribs, the contraction of the chest on the absorption of the effusion, and the flattening of the upper and anterior portion of the thorax as a frequent attendant upon advanced pulmonary consumption, as well as various alterations from internal tumours are well known to the profession. But the author believes that alterations occur at an earlier period of phthisis than has been taught by any writer,—that, in fact, the flat chest which has been held to predispose to phthisis is the consequence of it. Certain deviations, he believes, have not been described at all, and their mode of production, their relation to certain symptoms, and their salutary influences as defences of life, have received little attention. On these grounds, this contribution may be justified.

The frequency of acquired deformity of the chest from disease of the contents of that cavity, is very great. Of one hundred of the author's out-patients at the Brompton Hospital, fifty-three presented certain abnormal deviations from the natural form of the chest. Of the remaining forty-seven patients, whose chests were normal, only nineteen suffered from phthisis, seventeen of whom were in the first stage, one in the second, and one in the third. The affections of those other persons who had the chest in a normal condition were chiefly bronchial and cardiac.

I. The deviation which is most common is a general flattening of the entire front of the chest, including the sternum in the middle and the costal cartilage and the ribs for a space of an inch or two on either side. The two sides are generally symmetrical, or nearly so. The sternum has lost much of its gentle convexity on the exterior, and becomes nearly straight from above downwards, assuming, too, almost the perpendicular direction. This bone appears to have permanently approached somewhat nearer the spinal column than is natural. The costal cartilages have lost much of the roundness of their outlines. The second and third cartilages are often found perfectly flat. The lower cartilages, which in the healthy form frequently rise and form a ridge on either side of the sternum, both laterally and from above downwards are found divested of much of their prominence. The clavicles may retain their normal position or decline. The dorsal spine is usually found normal, or only a very little more rounded, posteriorly than natural, but in some instances the dorsal spine has its convexity materially increased, and it approaches the form of the gibbous back. The extent of the rise and fall of the front part of the chest in respiration is materially reduced, but the abdominal movements are augmented.

It is in phthisis that this deviation is most frequently found. It is comparatively seldom the result of internal thoracic disease without the presence of signs of tubercles of the lungs. The following table will serve to show at a glance the comparative frequency of this deviation in 74 examples of disease, which I have taken in strict succession from my Hospital book.

Phthisis.	Doubtful Phthisis.	Bronchial Affections.	Dyspnœa.	Heart Disease.
66	3	2	1	2

Of 63 other cases of phthisis, 44 were associated with abnormal deviations, and of these 21 had double flattening.

The flattened chest, or what, for the sake of distinction, may be called the double flattened chest, is found very early in phthisis and comparatively seldom in the more advanced stages, at least as the leading deviation. In the second and third stages it is replaced by other deviations of a more local and more striking character. The following table shows the proportion of 66 cases of double flattened chest to each stage of phthisis.

1st Stage.	2nd Stage.	3rd Stage.
49	12	5

In the 49 examples of double flattening of the chest in the first stage of phthisis, signs of tubercle in both sides were found in 40, while in only 9 were the signs completely restricted to one side. It is true that in most of the 40 examples of double phthisis the signs were more marked and the disease further advanced on one side than on the other. Of 12 cases of this deviation found in the second, or softening stage of phthisis, in 6 the disease was double, and in the same number it was single. In 5 examples of this departure from the healthy conformation occurring in phthisis at its third stage, good-sized cavities were found on one side, but there was in all the cases, implication, though not always to a great extent, of the opposite lung.

The female sex appears to present in a special manner the double flattened chest. Of 74 examples, only 29 occurred amongst males, being a rate of 39·1 per cent., while 45 were found in females, being a rate of 60·8 per cent. This excess in females does not extend to all deviations: in 152 examples of all kinds of deviations, 81 males suffered and only 71 females, or at the rate of 46·7 per cent. of females to 53·2 per cent. of males. And the proportions are reversed in single flattening, or flattening on one side, for of 43 examples, 33 occurred in males and 10 only in females, or at the rate of 76·7 per cent. in males and 23·2 per cent. in females.

Proportionate rate per cent. of sexes in double and single flattening, and in all deviations.

Double Flattening.		Single Flattening.		All Deviations.	
Males.	Females.	Males.	Females.	Males.	Females.
39·1	60·8	76·7	23·3	53·2	46·7

At all ages the double flattened chest is observed: comparatively few examples have been seen in childhood. Of the 74 cases, only 2 were found in persons at 10 years and under. No example in the 74 cases was found at 50 years or upwards. A large proportion of the ages ranged from 25 to 35 years. The average of the whole was 29 years and 2 months. The average age of males was somewhat higher than that of females, being 30 years 4 months, while that of females was 28 years and 5 months. The average age of 74 persons having the double flattened chest is rather lower than that of 47 persons, who had normal chests. The average of the former was 29 years 2 months, that of the latter 32 years 3 months. The average age of the 74 persons with double flat chests is much the same as that of 43 persons with single flat chests, to be afterwards referred to. The former is 29 years 2 months, the latter 29 years 11 months. The average age of males with double flat chests is slightly higher than that of males having single flat chests, the former being, as before stated, 30 years and 4 months, that of the latter being 29 years and 9 months; but the average of females with double flat chests is lower than that of females with single flat chests, the former being 28 years and 5 months and the latter 30 years and 6 months.

The amount of flattening varies in different cases from a moderate yet obvious reduction of the natural convexity of the upper portion of the thorax both in a transverse and vertical direction. The centre of the stetho-goniometer being placed upon the sternum, the two arms of the instrument placed upon the two sides of the chest respectively,—upon the second or third ribs, or between them, will be found nearly in a straight line. If the centre of the instrument be placed upon the costal cartilages, the angle to the tangents of the curves will frequently be found 175°, being, so to speak, nearly that obtained in measuring a plane.

The stetho-goniometer is not essential in dealing with this deviation, for the eye alone is sufficient to detect it, but it is of use in discovering a little difference between the corresponding parts of the two opposite sides, and in affording an accurate measure for record, and for future comparison, such as no mere mental recollection can bestow.

The deviation which is under consideration is not to be confounded with that loss of rotundity which proceeds from mere loss of flesh. In this case the bones, if accurately traced, are found to retain their natural curves. Attention too is to be given to the fact that flattening may be due to congenital formation or to posture, as in occupation. The evidence of the patient will serve to prevent error. The unhealthy flattening is frequently so marked that patients themselves will declare that their ribs and breast-bone have fallen in.

Though the double flattened chest is very generally associated with phthisis, and more particularly with it in its first stage, it is occasionally seen in mere bronchial affections, as will appear by reference to the table of diseases associated with the 74 cases treated of.

In examples of double flattened chests, pleural adhesions are, for the most part, found only at the apices, and in some cases only on one side of the chest.

The mechanism of the production of flattening in phthisis appears to be this. Masses of tubercular deposit, larger or smaller, and more or less numerous, having been deposited in the summit of one or both lungs, the admission of air into the vesicles thus occupied is of course prevented, and as the bulk of cells occupied with tubercular deposit is less than the bulk of cells filled or distended with air, the chest in the vicinity of the tuberculated lung, if the diseased portion be at all considerable, and such as cannot readily be compensated by the adjoining healthy structure, fails to rise in the act of inspiration. This will account for the loss of that fulness that obtains in full inspiration, but beyond this there is a flattening or actual sinking, apparently beyond the flattening of healthy expiration. The tuberculated lung occupies less space than the healthy lung which has just taken part in the act of ordinary expiration, frequently less than the lung which has taken part in a forced expiration. The lung under the process of tuberculization has actually undergone a contraction, and its tendency is to leave the walls of the thorax, but from the operation of the pressure of the external atmosphere and the elasticity of the cartilaginous and more yielding osseous parts of the chest no separation takes place, and these parts follow the retiring lung, and give rise to the flattening which we observe. The flattening seems likewise to be due in some measure to the fact that persons afflicted with phthisis at its commencement, purposely avoid making deep inspirations, and take into the lungs the necessary quantity of air in restricted and more frequent draughts. This substitution of restricted and more frequent for longer and less frequent inspirations will naturally be attended by a less complete distension of the air cells, and they, from their natural elasticity, will somewhat contract and draw the thoracic walls with them. In this way we shall be enabled to account for the disproportion whi
frequently seems to exist between the amount of
and the amount of flattening, the latter bei
quantity. It will also serve to account for

occurring on both sides of the chest in nearly equal amounts when there is reason to believe that the disease of the lung is confined to one side, or is much greater on one side than on the other. The patient is led to make short and more frequent inspirations, warned by the fact that full respiration is attended with local distress, and sometimes with pain.

The general flattening in phthisis and some other diseases is promoted by habits of stooping and holding the head and shoulder forward, as assistance in respiration seems to be obtained in this way. And it is to be observed that flattening of the chest may arise to some extent from weakness or listlessness, causing the stooping posture to be assumed.

The flattening of the healthy side, which is seen to attend the flattening of the unhealthy side, is occasionally overcome, and the healthy side returns to its normal configuration, or it may even manifest an abnormal elevation and expansion. This takes place when the lung, free from tubercle, taking upon itself the duties of the disabled organ, becomes hypertrophied, and carries on a compensatory respiration known as puerile breathing.

The flattening of the chest, and consequently the diminished power of distending the lung with air, appears not without some solid advantages to the patient. If the cells still free from tubercle and yet adjoining solidified structure were to be fully distended, laceration must ensue, and together with it, hæmorrhage, more or less copious and more or less fraught with immediate danger to life. As the case stands the danger of laceration does exist, and doubtless this accident frequently takes place and proves the cause of hæmorrhage in many cases, but the danger is greatly obviated by the reduced capacity of inspiration which attends the flattened chest. When laceration is spoken of, that amount which would admit the finger, or that can be readily seen after death, is not meant; but only a fine division, scarcely to be seen, yet in such a vascular organ amply sufficient to produce serious hæmorrhage. The flattening of the chest and the consequent reduced power of inflating the lungs, seem to be opposed to hæmorrhage only so long as no adhesions exist between the thorax and the lungs. When extensive adhesions have taken place between the lungs not yet totally disorganized, and the apex and upper part of the thoracic cone, hæmorrhage would appear to be invited. But of this the author has not yet been able to satisfy himself by the statistical test. Flattening with extensive adhesions, and a lung still vascular, would seem rather to favour hæmorrhage by exposing to laceration when the diaphragm forcibly or suddenly contracts.

II. Flattening of one side of the chest is a very important deviation from the natural conformation. In its slighter degree it is easily recognized; but in its more advanced, it is very striking, and forms a very remarkable contrast with the opposite side. In its full development, it is significant of very serious disease: in most examples it is the attendant of cavities in the structure of the lung beneath, of cavities which may be large with or without any healthy pulmonary structure interposed, or of cavities which are contracting and reduced to a fraction of the size they once possessed. In not a few cases the greatly flattened side is the monument of cavities long obliterated by the contraction of their fibrous walls.

In the single flattened chest the parts most implicated are the first, second, and third costal cartilages, and the anterior portion of the corresponding ribs. The natural convexity of the part as measured by that of the opposite side is reduced. The angle of its tangents taken with the stetho-goniometer is greater than natural by 5° or 10°. In many instances the instrument shows, so to speak, an angle of 180°, i. e. of a plane. Beyond this the depression may go, and an actual hollow be observed. The convexity of the exterior of the costal cartilages is replaced by a concavity. The centre of the instrument held near the lowest part of the hollow, and, as it were, opposite the apex of the curve, with its two arms held respectively on either side, and parallel with two tangential lines, the stetho-goniometer will show an angle of 185° in many examples of healed or healing cavities. Fig. 1, plate XI. (see Frontispiece), exhibits this deviation.

Associated with flattening on one side there is frequently found a compensating abnormal fulness and convexity on the opposite side. This proceeds from increased expansion of the lung. Puerile breathing is common. This compensatory fulness takes place only when the corresponding lung is but little or not at all implicated in the tubercular deposition. The rise of the costal cartilages, just as they leave the sternum, is sometimes very striking. On this side there is ample movement, while on the flat side there is very little motion or even absolute immobility.

While the flattening of one side may justly be regarded as *the* deviation of the case, there is also sometimes found a slight degree of flattening on the other side, associated with some loss of expansive motion at the upper part of the chest. In this case, while by far the greater amount of disease is present on the flat side, there is frequently found to be disease, though comparatively little advanced, on the more slightly flattened side.

In examples of great single flattening the loss of motion, though great, may be overlooked, for while the expanding movement of the ribs is reduced, and with it the expansion of the lung beneath, there is often present an increased movement of the clavicle and scapula, from voluntary exertions made to gain some little advantage in respiration, in some cases now become painfully difficult, and this may be observed more especially when the respiration of the patient is abnormally abdominal. The clavicles and scapulæ are frequently raised and fixed, in order to give greater effect to the inspiratory muscles, and to aid in the elongation of the thorax.

The flattened single chest, when limited in extent, and when marked in degree, is almost pathognomonic of phthisis, and when carried to a great degree, of phthisis in its third stage. Of late, in examining the chests of out-patients at the Brompton Hospital, the author has been able in numerous examples to predicate a cavity and its precise locality without putting a question, without percussion or auscultation, simply by ocular inspection, and by the discovery of the alteration under consideration. Of course the value of the prediction has in every case been tested by the usual examination. In examples of hepatization a great depression is found, but associated with this the shoulder is much depressed, and the base of the chest is contracted. In some examples of flattening, associated with hepatization, or that consolidation of lung which continues after empyema, the author has found signs of cavities, though doubtless small, surrounded by thick structures, and revealing themselves less plainly than in simple tubercular disease.

The value of flattening on one side is well illustrated by the following facts. Patients with this deviation have come to the hospital. Cavities have been strongly suspected, but the usual auscultatory signs have been defective. Months after, signs of large and evidently old cavities have been conclusively obtained.

The following table shows the proportions of 43 examples of single flattening to phthisis and other diseases:—

Phthisis, all stages.	Phthisis, doubtful.	Hepatization.	Bronchial Affections.
40	1	1	1

This deviation occurs in all stages of phthisis, but more especially in the third. It is common in the first, but in a less advanced degree. But it is in the third stage that the marked form is most frequently observed. The following table shows the proportions of this deviation to each stage of phthisis out of 40 examples:—

Phthisis, 1st stage.	Phthisis, 2nd stage.	Phthisis, 3rd stage.
13	7	20

The observation of fewer examples of depression in the second stage than in the first seems to require some explanation, and is probably to be found in the fact that comparatively few persons come to the hospital in the second stage, the greater number coming in the first and third, a fact again explained by the shortness of the second stage compared with the others. The period of softening which comes between the two other stages is short, and is soon replaced by unequivocal signs of cavities of some considerable size, which with the author has been held to constitute the third stage. It may further tend to explain the paucity of this deviation in the second stage, if it be stated that the evidence of deviation was taken on the first examination and then only. This may also be held to argue that deviations are even more common than appears by the tables in this paper, for doubtless many persons in the first stage and in the second would, after a time, and after the evidence had been taken, become the subject of various alterations of the chest.

The frequency of the concurrence of cavity with the presence of flattening or hollowness on one side, is further well shown by the following table, which exhibits the form of chest in 39 examples of well marked cavities.

Table showing the form of chest in 39 examples of cavities :—

Form Chest.	Healthy.	Flat on one side.	Flat both Sides.	Angularity one side.	Angularity two sides.	Total.
No. of Cases.	1	20	5	11	2	39

The almost constant attendance of flattening at least on one side in cavity cases, is further well illustrated by the following facts ascertained a few days back, when the author was doing duty for Dr. Cursham and Dr. Thompson. Of eight women in one ward under Dr. Thompson, seven had cavities. Of these only one had a prominent and symmetrical chest, and her cavity had been only lately made out. The other six females presented one or other deviation; four had flattening marked, though not extreme; two had the ribs and cartilages angular at their junction, and the ribs retiring rapidly backwards on the cavity side. Of seven men—patients of Dr. Cursham — having cavities in the lung, not one was free from some deviation. There was flattening in four, and flattening with angularity in three. The deviations in the males were certainly more marked than in the females.

Great depression on one side is frequently to be found in persons who have very extensive cavities underneath, and yet have no inconsiderable amount of health and strength. In many such persons the complexion of the face is florid, or of a bright nut-brown colour, the condition in respect to adipose deposit, is that of *embonpoint*. The pulse is calm, and the impulse of the heart is increased in area, and is felt, and even seen as high as the first interspace. It was only a few days ago that a young woman came to the hospital blooming like a country milkmaid, saying that she feared her disease might return if not attended to at once. The left subclavicular and mammary regions were found hollowed, and beneath was discovered an enormous cavity in the lung. This patient had been an inmate of the hospital on three different occasions. In a few days she was so well that she desired to be discharged.

Such facts as these, and they are constantly presented, requiring no colouring, have led the author to the conclusion that single flattening is part of a great healing and defensive process. The walls of the cavity come together, and the yielding hard parts follow, and the inflating chamber is reduced in magnitude. Unless the hard parts sink in, it would be comparatively difficult for cavities to heal. If the chest continued to expand, the cavity would continue to be alternately filled and emptied with every inspiration and expiration, and to the manifest injury of the diseased part and of the patient.

When marked flattening on one side presents itself, with material tendency to loss of flesh, however successfully combated for a time, and with failing health, particularly if associated with inclination of the one border of the sternum backwards, the author regards the presence of a cavity as almost certain, even in the total absence of pectoriloquy and gurgling. On subsequent examinations these and other signs have converted a presumption into a certainty. It was only yesterday that a cavity large, old, and dry, was fully made out for the first time in a man who, on his first examination a month ago, presented flattening with one border of the sternum inclined backwards, but without one of the positive signs of that condition.

Flattening confined to one side, in a marked degree at least, has been found in the author's experience to be more frequent in males than in females, which is the reverse of what holds in the case of double flattening. Of 43 well-marked examples of single flattening, 33 occurred in males and only 10 in females. The author cannot say that males display this distinction uniformly in excess. The excess here may be due to accidental causes, and would perhaps not hold in a larger number of observations. The excess in this collection of examples may be explained by supposing that men do not come to the hospital until their disease is further advanced than in women upon their first application. It may likewise be explained by supposing that males, having more power of endurance, live longer with cavities, and thus have more time afforded for retraction of the chest. The author has not yet been able to analyse the facts before him, so as to come to a satisfactory conclusion on these points. The greater power of the male constitution, favouring as it must do the deposition of false membrane, and of a more vitalized lymph, probably assists in making the depression more complete and more frequent in males; at the same time it cannot be forgotten that the greater pliability of the bones and cartilages of females must favour depression of the chest in them.

Single flattening occurs at all ages. It does not appear to be more common in childhood when the bones and cartilages are more particularly pliant than at middle age. Of the 43 examples of this deviation, 3 occurred at 10 years and under. Instances of greater age were found in this category than in the double flattening. One male was 56 years old, and other five persons had attained to 45 years and more. The average age of both persons was 29 years, 11 months. The average age of males was 29 years, 9 months; and of females, 30 years, 6 months.

The mechanism of single flattening or hollowing appears to be this. It is the mechanism which holds in double flattening, to which is superadded the mechanism of the retraction of the thorax in permanent hepatization and of pleurisy, or which follows empyema. In the third stage of phthisis much of the structure of the lung and much of the tubercular deposit is expectorated, and a vacant space is left, called a cavity. When the parts which form the walls of this cavity are of tolerable thickness, and consist in great measure of thickened pleura and a mass of condensed lung structure, mixed up with much fibrinous deposit, and free from a copious admixture of mere friable ever detaching tubercle, the cavity contracts, and the walls drag the whole neighbouring parts towards them. The adjoining pulmonary structure and pleura pucker, the intercostal spaces are drawn in, and at length, if life continue long enough, the costal cartilages and ribs are bent in under the persistent traction. The longer life continues, the greater and the more remarkable the flattening, or, as the case may be, the depression or the actual hollowing becomes, until the cavity has finally ceased to exist, and the blended walls no longer contract. The traction power of the walls of tubercular cavities and of abscesses in the lungs is quite sufficient to produce this deviation from the natural form of the chest. The author has known several examples of tubercular cavities nearly obliterated, and surrounded by a considerable mass of indurated lung structure, and surmounted by thickened pleura and false membrane attached to the anterior and superior portion of the thorax, to suffice not only to depress the ribs and cartilages, but to drag over to the right side of the sternum the heart, and to cause the hypertrophoid lung of the left side to invade the right side of the thorax. Dr. Walshe has pointed out this traction power exerted upon the heart. The author examined the body of a young man a year ago, who died under these circumstances: a small cavity in the right lung, surrounded by very hard cartilaginous-like lung tissue, the heart on the right of sternum, and the hypertrophied lung of the left side inflated and resisting, invading the right side of the chest. More recently a young woman, named Thrush, under the care of Dr. Cursham, died in the Brompton Hospital. During life the heart had been felt to beat much at the second right interspace.* The only structure at the right apex was a mass of hard contracted puckered material, composed of lung tissue, fibrinous deposit, and some cretaceous matter, the remains of a cavity. The right bronchus was very greatly dilated, having been doubtless occupied and distended with air, tending together with the dragged heart and the depressed ribs to occupy the space left vacant. A small tubercal cavity was found on the left side. A cavity had doubtless been present on the right, but had become obliterated in the manner above described.

Pleural adhesions are generally present in cases of great flattening. The author has not seen any cadaver opened with this deviation to a material extent from the natural form, without finding such adhesions; but he inclines to the belief that they are not essential: the tendency to contract and to occupy a smaller space on the part of such lung and other structure as is under consideration, must necessarily be attended with a following of surrounding parts to an extent commensurate with their ability to move or yield, or, it may be dilate like the hypertrophied lung, or a dilated bronchus.

All cavities do not tend to become less: some indeed even tend to become larger from the constant falling in of tubercle as the dimensions of a quarry increase by the constant falling in of fresh material. When the tubercle is in numerous masses of a friable nature surrounded by soft suppurating lung tissue, the cavity extends, until rib-ways there is nothing left but a thin membranous wall of pleura and not very firm coagulated lymph. In such cases very little or no flattening takes place from contraction of the walls of the cavity, and in some cases the author believes that instead of depression of the ribs progressing as in the cases formerly referred to, the flattening which had taken place, during the period of crude tubercle tends to be reduced and the ribs are again disposed to rise under the influence of an increased respiration, not vesicular it is true, but cavernous, which admits a large amount of air with readiness under them within the flaccid cavity. The author believes he has seen the ribs rise and depression be reduced under the formation of such cavities. The lung rendered impermeable to air by the presence of tubercle, has become very readily pervious, nay, inflatable, like a bladder, by the rapid removal of a great mass of friable tubercle, now leaving thin expansive walls.

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* I deem it due to Dr. Cursham to say that he has kindly given me permission to mention this case, and that he has on numerous other occasions placed his valuable materials at my disposal.

That such a tendency to expand exists, there is no doubt, not only during inspiration, but under other circumstances. During the act of coughing, how often has it happened to the author to see the process of expansion made visible by the forcible filling out of the intercostal spaces in hernia-like forms in cases of cavities with thin non-contracting walls. The presence of cavities in such cases being sufficiently proven by the *bruit de pot felé*, whispering superficial pectoriloquy, and other conclusive signs.

III. An angular condition of the articulations of the upper costal cartilages with the sternum is not unfrequently observed as the product of disease. Instead of the articulations forming part of a gentle curve, in which the sternum and cartilages participate, they form angular points, whence the cartilages and bones depart at an angle varying in degree in different cases. The angle as measured by the stetho-goniometer is frequently one of 160° or 155°; the part most affected is the second articulation counting from above. When the angle is sharp the articulation is sometimes found swollen, and resembles in some cases the mastoid process of the temporal bone. In this condition the part is generally tender. When this deviation is considerable, the costal cartilage retires fast backwards and may have lost much of its gentle convexity. The sternum maintains for the most part its normal transverse situation.

This deviation occurs on one side only, or on both sides. Of 32 patients, in whom this angularity was the prevailing deviation, and whose cases have been taken for analysis, 22 occurred on one side, and 10 on both sides.

The sexes suffer in nearly the same proportion. Of the 32 patients, 17 were males and 15 were females. Females seem to present angular deviation on one side as frequently as males, there being 11 of either sex, which is different from the case of single flattening, the number of males being 33, and of females 10, out of 43 well marked examples. This special fact, which perhaps indicates a more general fact, may be explicable by the greater narrowness of the female thorax and the consequent disposition to angular formations upon slight bending.

The angular feature may not be restricted to the articulations of the sternum and the cartilages. It is not unfrequently seen at the articulation of the ribs and the costal cartilages. The parts seem at these points suddenly and abruptly to separate, and to pursue different directions. The angle is sharp, and may vary from 160° to 150°. These articulations are seldom swollen or painful.

The natural dimensions of the chest in such cases have for the most part been originally great from above downwards, rounded in the circumference, and decidedly narrow. This has been observed both in males and females.

This angular deviation has been noted at all ages, from the child, of either sex, to old age, but it has shown a preference for children and those of them suffering from dyspnœa and bronchial affections as well as consumption.

Associated with this angularity on both sides or on one, there has been observed in many examples a decided sinking of the ribs from above downwards. This has been most striking when the deviation has been on one side only. It was then more satisfactorily proven by the contrast afforded by the opposite side. In such cases the two upper ribs have sunk and a certain approximation to each other has been seen to hold with the three upper ribs. The clavicle, too, has sunk, retired rapidly back as it progressed outwards, and the articulation of the clavicle with the sternum was, as it were, opened and seemed to gape, so as to admit of the insertion between the two bones of the tip of the finger.

The angular deviations if recent, are generally associated with serious disease. In children the producing disease may be bronchitis, pneumonia, hepatization, or affections of the heart, attended with some impediment to respiration, particularly to inspiration. But in the majority of the examples which I have analysed, double marked phthisis was present.

Table showing diseases and stages of phthisis in 10 examples of undue angularity of both sides.

Functional disease of heart.	Phthisis. 1st stage.	Phthisis. 2nd stage.	Phthisis. 3rd stage.	Dilatation of heart.
1	3	3	2	1

Of the above 8 examples of double angularity associated with phthisis, this disease was confined to one side in two only.

IV. Undue angularity on one side, if marked, is significant of serious disease, more than double angularity if moderate.

Of 22 examples of the single form of this deviation, eleven, or one half, were associated with phthisis in its third or cavity stage.

Table showing stages of phthisis and other diseases in 22 examples of augularity on one side.

Ph ?	Phthisis 1st stage.	Phthisis 2nd stage.	Phthisis 2rd stage.	Hepatization.	Bronchial affections.
1	5	3	11	1	1

The mechanism of angularity seems to be much the same as in flattening, with the addition of yielding or bending of the articulations. This additional feature is in part due to a greater narrowness in the chest that has been found to exist, or in other words to the front curve of the chest belonging to circles of smaller radii. The angularity seems likewise to be assisted by dyspnœa: the forced inspirations raise the sternum, while there is reason to believe the more free and loose parts of the ribs tend to be drawn inwards and downwards by exertions of the diaphragm, particularly when the articulations are not very firm. In some cases the sternum has appeared to be supported by the action of the external muscles the greater and smaller pectorals, while the diaphragm, and perhaps the triangularis sterni have depressed the ribs, &c.

V. Certain acquired prominences are occasionally seen in the configuration of the thorax. These proceed from internal tumours, from aneurism, and from enlargement of the heart. In plate XI., fig. 3 (see Frontispiece) exhibits a not uncommon form of projection from hypertrophy of the heart. Such a deformity is readily measured with the goniometer, and one side is accurately contrasted with the other.

VI. The sternum is very frequently the seat of deviation from its natural position and form. It is in childhood chiefly that deviation in form takes place. Instead of presenting a gentle convexity outwards and from above downwards, this bone may be perfectly plane or it may be concave. It is frequently raised and projecting throughout as in the pigeon-breast; the chief characteristic may be an angular prominence at the junction of the upper and middle portions of the bone, the upper part suddenly departing from the line of the middle part, and directing itself towards the trachea. The junction of the middle part with the ensiform cartilage, frequently forms an angular projection. The ensiform cartilage may be almost horizontal, while the middle portion of the bone may be perpendicular, or inclining back as it rises. The author has seen this articulation form an elbow. These deviations have usually arisen in childhood while the articulations have been feeble, or the bones particularly pliant. Distortions may arise at other parts before the bone has acquired firmness, or when the natural firmness is absent, as in rachitis.

The weight of the head and superior extremities seems in cases of rachitis greatly to tend to deformities of the sternum, but as has been well shown by Dr. W. T. Gairdner in the "Edinburgh Journal of Medical Science" for 1851, bronchitis and other chest diseases attended by dyspnœa are very frequent causes of the deviations from the natural form and position of the sternum as well as of the ribs. The author has seen several infants in whom great sinking of the ribs and elevation of the sternum have been in actual progress. The thorax along the course of the insertion of the diaphragm has been greatly depressed at every inspiration. In one remarkable example great dyspnœa was present, and after death the heart was found to be single and the pulmonary arteries taking their origin from the aorta. The chest goniometer is specially adapted for the measurement of these deviations.

Though phthisis and other diseases in the adult comparatively seldom give rise to alteration in the form of the sternum, they occasionally succeed in so doing. In some examples of phthisis, the author has seen the upper portion of the sternum manifestly drawn towards the trachea, when the action of the diaphragm has been forced, in consequence of more than usual dyspnœa. The same thing has been observed in severe chronic bronchitis, and in cases of long standing organic diseases of the heart. Cancers in the mediastinum, when extensive, will raise the sternum and impart an undue roundness and prominence to it. Aneurism of the aorta produces a similar result.

The deviations of the sternum which it is desirous more particularly to point out here, are those which relate to its position. In phthisis the author has remarked that the sternum very frequently loses its normal position in the transverse plane of the body. In almost all examples of old cavities in the apices of the lungs attended with flattening, the sternum is found to have its transverse plane deviating from the transverse plane of the body. The edge of the sternum nearer the flattened cartilages and the cavity is directed backwards or to the interior of the chest. The sternum will be found to have rotated on that border which is nearer the sound side, to make in some cases an angular projection, and the transverse surface of the sternum, and the corresponding costal cartilages form one straight line. The depressed and retracted cartilages have succeeded in dragging the sternum with them.

This inclination of one border of the sternum to the interior of the chest usually holds with the bone throughout its whole length, but it may be more above than below, in which case the sternum acquires a somewhat twisted appearance.

But the deviation may not stop here. The sternum is not unfrequently at its upper part dragged over towards the cavity or the retracted side, and it thus loses its exact position in the middle of the body. It pursues an oblique course, and when twisted as above described presents a very remarkable appearance, and one almost always conjoined with phthisis in the third stage or with extreme hepatization, but much more frequently with the former.

At the present moment there is a fine example of lateral deflection of the sternum under consideration in the Brompton Hospital under Dr. Cursham. The patient is a lad named Brown, of about 17 years, having a large cavity on one side. In the same ward Dr. Cursham has another patient, with this deviation less marked. The patient is a man of about 55 years, and he too has a cavity in the lung. The sternum is occasionally seen inclined towards the healthy side in cavity cases, dragged over by excessive expansion of the ribs.

Though the clavicles and scapulæ cannot strictly be said to form part of the thorax, it may not be without advantage to devote a few words to their behaviour in disease of the organs of the cavity of the thorax. The rising of these bones in cases of dyspnœa, emphysema, and empyema is very commonly known, but the lowering of them, though common too, is perhaps less attended to when proceeding from thoracic disease. In almost all examples of flattening, angularity, and retraction of the chest, these bones are the seat of deviations, greater or less, in their position. In single flattening these parts simply decline; the clavicle sinks as it proceeds outwards from the middle of the body. In cases of angularity where the ribs bend back abruptly, the clavicle frequently does the same, as ascertained either by the chest-goniometer; and the sterno-clavicular articulation is, as it were, laid open, and the finger may be partially introduced between the extremities of the two bones. The sterno-clavicular articulation of one side may be found much posterior to the other when the sternum at one border has inclined inwards. A boy is now under the author's care at the Brompton Hospital with a large cavity on the left side, whose left sterno-clavicular articulation is more than half an inch behind the other. In this case the fact attracts the more ready notice from the sterno-cleido-mastoideus of the right side standing out in consequence much more prominently than the other. The clavicle in this case, like the ribs, retires rapidly backwards.

VII. Lowering of the clavicle and scapula from descent of the upper ribs, consequent upon contraction of the lungs, is occasionally noted where there is comparatively little flattening in front; and where there is no curvature of the spine and no reason to attribute the change to mere posture, it may assist in diagnosis. It is a weight, though a light one, to be employed in estimating the probabilities of internal disease.

VIII. Depression of the first and second intercostal spaces on one side is occasionally seen without the presence of any other deviation. The depression is seen most frequently near the sternum. It appears to be a preliminary to the more general flattening. In some examples of flattening and hollowing of the costal cartilages, the depression of the interspaces is very marked, and outstrips the other flattening. A young German named Koch in the Hospital, under Dr. Thompson, who has great flattening from a cavity, presents the interspaces remarkably hollow. They appear as if the thumb had been deeply pressed into them.

The influence of disease in producing deviations from the natural form of the chest has been fully shown by the foregoing facts, which seem to be sufficiently numerous for the purpose. They might have been greatly extended, though, it is believed, with no corresponding advantage.

There yet remain two points to be mentioned. The first is that phthisis in its third stage, though almost always associated with deviation from the natural form of the chest, is occasionally seen without any obvious deformity, and may be associated with actual prominence over the cavity. A very fine large woman in good condition came to the Hospital. The left sub-clavicular region was full and prominent, but to the surprise of the writer all the usual signs of a large cavity immediately beneath were discovered. Dull percussion, cavernous breathing and pectoriloquy were present. The explanation of this anomaly was found in a moderate curvature of the spine, which threw up the left shoulder and thrust forward the left side of the thoracic cone. The second point is this,—that deformities of the chest, such as have existed from childhood, do not appear to favour the advent of phthisis. Comparatively few of the many examples of long standing, or, so to speak, of infantine deformity of the chest, which have presented themselves to the author at the Hospital, have been associated with phthisis. The diseases more especially observed have been chronic bronchitis recurring at intervals, some dyspnœa usually persistent, and disordered action of the heart. The explanation of this fact is probably to be found in a comparative immunity from tubercular tendency, which has been proven by bronchitis and other diseases having arisen under circumstances which are perhaps calculated to induce tubercles in others. Dr. T. W. Gairdner years ago proved that bronchitis and other diseases, not including phthisis, were the most frequent causes of the chronic deformities of the chest, and though these disorders may not exactly prove antagonistic to consumption, their presence and its absence rather argue a non-disposition to the production of tubercle, which probably holds in after life, and evinces itself in the fact now stated, viz., that comparatively few of the deformed chests presented at the Consumption Hospital are found to be associated with consumption,—at least, so far as the author's observations extend.

Table showing the proportions of each kind of deviation in 151 examples, with the respective numbers of each sex.

Flattening, both sides.		Flattening, one side.		Angularity, both sides.		Angularity, one side.		Preternatural Prominence, partial.		Total Males.	Total Females.	Total both sexes.
M.	F.	M.	F.	M.	F.	M.	F.	M.	F.			
29	45	33	10	6	4	11	11	2	0	81	70	151

THE DIFFERENTIAL STETHOPHONE, AND SOME NEW PHENOMENA OBSERVED BY IT.

[*From the Proceedings of the Royal Society, No.* 31, *Vol. IX.*, 1858, *communicated by Prof. Tyndall, F.R.S., and read April* 22, 1858.]

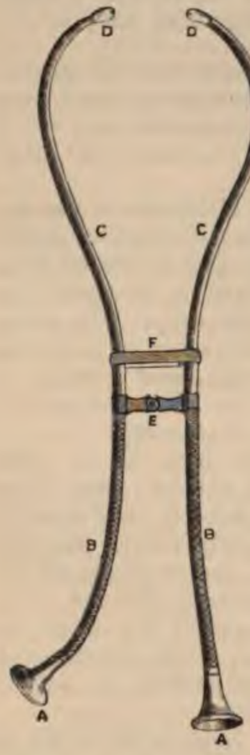
Engaged for some years in investigations into the phenomena of audition, I have become cognizant of some facts which I believe have hitherto remained unnoticed, and which are certainly not generally known to physicists and physiologists.

The first of which I shall treat is the restriction of hearing external sounds of the same character to one ear, when the intensity is moderately, yet decidedly, greater in one ear than in the other, the hearing being limited to that ear into which the sound is poured in greater intensity. The sound is heard alternately in one ear and in the other, as it is conveyed in increasing degrees of intensity, and hearing is suspended alternately in one ear and in the other, as the sound is conveyed in lessening degrees of intensity.

Sound, as is well known, if applied to both ears in equal intensity, is heard in both ears; but it will be found, if the intensity in respect to one ear be moderately yet decidedly increased, by bringing the sounding body nearer that ear than the other, or otherwise, as by the employment, in respect to one ear, of a damper or obstructor of sound, or in respect of the other ear, by the employment of some intensifier, or good collector or conductor of sound, the sound is heard in that ear only which is favoured and has the advantage of greater intensity.

There is little doubt that this law holds with regard to sounds passing through the air, and carried to the ear in the ordinary manner, without the aid of any mechanical contrivance, as for instance those of a watch placed in front of the face; but as the restriction of hearing to one ear, and its suppression in the other, admit of being rendered more obvious by an apparatus that shall collect sound, prevent its diffusion through the air, and carry it direct to the ear, I propose to give the results of experiments made with an instrument which I have invented for hearing with both ears respectively, and which, as it is specially adapted for the auscultation of differences in the sounds of different parts of the chest, I have named the Differential Stethoscope, or Stethophone.

The results thus procured will be more satisfactory than those obtained by ordinary audition; a sound will be increased as a visual object is magnified by the microscope, and as both ears are similarly dealt with, a perfect parity of conditions will hold in respect of both ears.



The differential stethophone (see figure) is simply an instrument consiting of two hearing-tubes, or trumpets, or stethoscopes, provided with collecting-cups and ear-knobs, one for each ear respectively. The two tubes are, for convenience, mechanically combined, but may be said to be acoustically separate, as care is taken that the sound, once admitted into one tube, is not communicated to the other. The tubes are composed of two parts nearly equal in length, one near the ear-knob, made of metal (C); while the other part, near the collecting-cup, is made of metal wire (B), to impart flexibility. The ear-end is curved, so as to approach the ear, and is supplied with an ivory knob (D) for insertion into the meatus externus. The other end of the tube, being intended to collect sound, is supplied with a hollow cup, or receiver (A) made of wood, or some such material. The mechanical construction of this instrument is borrowed from the stethoscope contrived by Dr. Caman of NewYork, and intended by its inventor for the purpose of hearing with both ears sounds emanating from *one* point, and collected into one cup. The two tubes are brought near together, a few inches in front of the face, by means of a connecting-bar (E), but calculated to prevent the transmission of sound from one tube to the other. This bar is supplied with a joint, which permits the tubes to be freely moved, as is necessary in applying the knobs to the ears. The two knobs are kept steadily in the ears by means of an elastic band (F) connecting the two tubes near the bar already described.

The instrument being fitted into the ears, with the knobs directed upwards, and the cups being applied equally near to, or upon a sounding body, say the inflating lung, or a watch, and the conditions for collecting sound being the same, the sound is heard with both ears, as in ordinary hearing. But if one cup be removed a little, say a half or a quarter of an inch from the *watch* (for we shall now adopt it), and the other cup be left upon the watch, the sound is heard with that ear only which is connected with the cup placed upon the watch, and the sensation in the hearing ear is so marked, as to leave the mind in no doubt whatever that it is through that ear we become conscious of the sound. If the cup placed upon or nearer the watch, be removed a little further than the other cup, so as to be less favourably situated for collecting sound, say one inch from the watch, the ear connected with it becomes totally unconscious of sound, and the sensation of hearing is most unequivocally felt in the ear, and in that ear only, which but a moment before was utterly deaf to it. If one cup be placed upon the middle of the watch, and the other on the edge, the watch sound is heard in that ear only which is connected with the cup placed upon the *middle*.

These experiments may be thus varied, and the result will in reality be the same, though apparently more remarkable. The watch, being held in the air, at the distance of about an inch from one ear, is heard distinctly beating into that ear only; but if the watch be now connected with the collecting-cup of the tube of the stethophone, inserted into the other ear, the sound, being greatly magnified, is heard in this ear, and in it only, the ear in which the sound had been primarily heard being now altogether insensible to it, or unaffected by it as far as our consciousness is concerned. The sensation of sound is transferred from one ear to the other, although the watch is allowed to remain in close proximity to the ear that is now deaf to its sound.

A watch placed upon or inside the cheek, is heard to beat in that ear which is nearer; but if the opposite ear be connected with it by means of one of the arms of the stethophone, or by a common flexible stethoscope, the watch sound is no longer heard in the ear nearer the watch, but in the ear further from it, which is now acoustically brought into nearer connexion with it, by means of the hollow tube.

Sounds, produced in whatever material, are alike subject to this law, so far as my experiments have yet been made.

The medium in which sounds are produced does not alter this law. A watch ticking, or a bell ringing, either in the air or under water, affords the same results.

Sounding bodies give the same results when covered with soft or hard materials. A watch placed in one corner of a box, a few inches square, and an inch deep, is heard to beat in that arm of the stethophone only which is near it. By this means, and by successive movements of the instrument, and by attending to degrees of intensity, the exact position of the watch may be with certainty indicated. Or this may be effected by successively excluding those parts which fail to cause hearing in one of the ears.

The interposition of a body calculated to obstruct the sound at its entrance into one of the cups of the stethophone, causes the sound to be heard in that ear only which is connected with the cup which remains free from obstruction. This admits of ready proof, by applying the two cups as much as possible equally on the middle of a watch about an inch above it, and by placing two fingers held together between one cup and the watch. When this is done, the watch is heard to tick into the ear that remains free from obstruction.

The removal of an obstructing body from one cup, while it is allowed to remain in operation with the other, causes sound which had been equally heard with both ears, to be heard in that one only which is connected with the cup freed from the obstructing body. Thus, if the fingers be interposed between the watch and the cups held equally over it, and the fingers be separated under one of the cups, so as to permit of atmospheric communication, the sound is heard in that ear only which is connected with this cup, and not at all in the other.

The effect of intensification of a sound in one ear depriving the other ear of all sensation of that sound, is interestingly shown by placing the *tubes* of the instrument across a block of wood with the cups hanging in the air. While both cups are left open, and a tuning-fork in vibration is placed between the two tubes, the sound is heard with both ears; but if one cup be closed with the hand, or with leather, and the other be left open, the sensation of sound is restricted to that ear connected with the closed cup. The sound in the tube connected with the closed cup is rendered more intense by the closure, the escape of sound is obstructed, and reverberation takes place. By virtue of the intensification, sensation is monopolized by one ear, and is lost in the other. The result and the mechanical conditions are much the same as in the experiments of Mr. Wheatstone with a tuning-fork held upon the head, presently to be referred to.

It is worthy of observation, that in order that a sound previously heard with or in both ears, as in the above experiments, may be appreciated or felt in one ear only, it is not necessary that the stethophone, or other conducting instrument, be placed in the cavity of the meatus externus. It is sufficient for this result that the instrument be placed near the meatus, so as to give it an advantage of intensity over the opposite cavity. When the instrument is to be held only near the meatus, care should be taken not to touch the external ear, so that there may be no conduction by that part from contact, which would vitiate the experiment. The result is perfectly satisfactory and conclusive, although the remarkable sensation of *pouring in* of sound into the ear is less marked,—a fact sufficiently intelligible from the diffusion of sound which must take place outside the ear, when the extremity of the tube is held there, and is not inserted into the meatus. It is therefore obvious that the restriction of hearing to one ear, under the conditions specified, is not due to closure of the meatus externus, the cause of the augmentation of sound in some experiments of Mr. Wheatstone, to be shortly referred to.

The remarkable phenomenon of the restriction of hearing to one ear, above described, seems not to be without important signification. It holds apparently in virtue of a law seemingly established for the purpose of enabling man and the lower animals to determine the direction of the same sound, with more accuracy than could be done had a judgment to be formed between the intensity of two similar sensations in the two ears respectively. All source of error is removed by there being only one sensation, although there may be two impressions. This law of a stronger impression in one ear, rendering us unconscious of a weaker, but similar impression in the other, has an analogue, though perhaps an imperfect one, in the sense of touch. Very strong impressions upon one part of the body cause such acute sensations, that minor impressions of the same kind upon another part are frequently not felt, in fact, produce no sensation.

The only observations bearing upon this law which I have been able to discover, are some by Mr. Wheatstone, in a paper entitled "Experiments on Audition," published in the

"Quarterly Journal of Science, Art, and Literature," vol. ii. New Series, 1827. These experiments are intended to show the augmentation which the sensation of autophonic sound, and of the sounds of a tuning-fork applied to the head, acquires when the ear is closed, although the perception of external sounds is diminished. Mr. Wheatstone shows that a vocal sound is heard louder in that ear that is closed, say with the finger, than in the other. He also shows, that the sound of a tuning-fork placed upon the head is heard louder in that ear which is closed than in the other which remains open, even though the tuning-fork may be brought nearer the open ear than the closed one. These experiments, Mr. Wheatstone says, prove that "sounds *immediately* communicated to the closed meatus externus are very greatly magnified;" and he adds, "it is an obvious inference, that if external sounds can be communicated to act on the cavity in a similar manner, they must receive a corresponding augmentation."

This distinguished philosopher constructed the instrument named a Microphone, for the purpose of augmenting weak sounds upon this principle, i. e. the augmentation of sound by closure of the ears; and he informs us that it "is calculated for hearing sounds when it is in *immediate* contact with sonorous bodies," and that "when they are diffused by their transmission through the air, this instrument will not afford the *slightest assistance*." This instrument is spoken of in connection with the augmentation of sound, and not in reference to the limitation of sound to one ear, or to the comparison of sensations in the two ears. The remarkable, and, to the uninitiated mind, the wonderful fact, made known more than thirty years ago by Mr. Wheatstone, that a tuning-fork held upon the head close to an open ear is not heard in this ear, but in the opposite ear, provided it be closed with the finger, or by some other means, proved that sounds communicated to the skull were exclusively heard in the closed ear. In the case of the tuning-fork, the fact made known by Mr. Wheatstone is undoubted. The rationale of the phenomenon appears to be this:—The vibrations of the tuning-fork are communicated to the bones of the head, and through them to the ears, including their bones, cartilages, and contained air; but in the case of the closed ear, the vibrations are permitted no egress or escape, as in the open ear; reverberations take place, and the consequence is, that the sound is not duly moderated; and in virtue of the law I have just enunciated, the sensation of sound is restricted to the closed ear. When the tuning-fork, duly sounding, is held in the air, and not connected directly with the head, the closed ear remains insensible to it, and the sound is heard exclusively in the open ear.

Mr. Wheatstone's interesting observation relates to a head-sound not duly moderated, as in the opposite and open ear, and virtually more intense, and comes within the general law advanced in this paper, which embraces all sounds, whether internal or external, viz. that a sound of the same character in the presence of both ears, if conveyed by any means to one ear, or to the nerve of that ear, more intensely than to the other, is heard in the more favoured ear only.

It seems necessary, in Mr Wheatstone's experiments, that the bones of the head shall vibrate freely; weak sounds, such as gentle blowing, will not succeed; and if the tuning-fork be placed immediately under the open ear, and passed upon the soft parts, little fitted for vibration, between the mastoid process of the temporal bone and the lower jaw, the sound is heard in this ear, and not in the closed ear.

It may perhaps be well, before proceeding further, to acknowledge that I am well aware it has long been known that a very loud sound conveyed into the ear will render the other ear insensible to sound of a weak or low character. But the phenomenon which I have ventured to bring under the consideration of the Royal Society differs from this well-known and readily admitted fact in this important particular, that no very great loudness is required, and that no very great augmentation of sound in one ear over that in the other is necessary in order to restrict the sense of hearing to one ear, and to deprive the less favoured ear of the sense of hearing which it had previously enjoyed. A moderate, yet a decided increase of intensity is all that is required to remove the sense of hearing from the less favoured ear, and to cause the more favoured organ to be alone sensible to the sound.

When sound is proceeding into the two ears, but in consequence of its reaching one ear in greater intensity than the other is heard only in one ear, the sensation of hearing in the favoured ear, though strictly limited to it, is augmented by the sound entering the less favoured ear, although it entirely fails to cause a sensation there, or to produce a consciousness of sound in that organ. The more sound collected by the less favoured ear, as long as the amount is less than that conveyed to the other ear, the more the sensation of sound is augmented in the more favoured ear. The intensity of sensation in the more favoured ear increases in a ratio with the increase of sound in the less favoured ear, until the intensity of sound is the same, or nearly the same, in both ears, when the sensation experienced is the ordinary one of hearing with two ears.

This fact admits of satisfactory proof in this way: — A watch is placed on a table equidistant from both ears. The stethophone is applied to the ears; one cup is placed within an inch of the watch, while the other is turned away from it, at the distance of some inches. As the further cup is brought nearer and nearer the watch, the sound, *always* confined to the more favoured ear, is gradually and steadily intensified, until the two cups are, or are about to be, similarly placed, at which moment the sensation ceases to be restricted to one ear, and has acquired its greatest intensity. This fact proves, that though the sensation of hearing be confined to the ear to which sound is communicated with greater intensity, we profit by the sound which is conveyed into the other ear, though failing to produce a sensation or a consciousness of sound there, by its serving to augment very materially the sensation of sound in the more favoured ear. The less favoured ear thus augments the sensation which we experience, at the same time that it fails to interfere with the aid which the sensation confined to one ear affords us as to the direction of external sounds.

The sounds of which we have been treating as differently affecting the two ears, according to the intensity with which they are respectively communicated, are of the same character, though differing in intensity. It is sounds of the same character only which exhibit the phenomenon of restriction in virtue of moderately different intensity. The sounds must emanate from the same sounding body, or from bodies sounding similarly. A little difference in *character* will cause the experiment of restriction to fail.

Thus, if two bells, differing considerably in character, be rung respectively in the two ears, one louder and graver than the other, the louder and graver sound does not render the other ear insensible to the weaker sound of the weaker bell. Both ears hear perfectly, but the loud, grave sound is heard in one ear, and the weak sound is heard in the other.

If, instead of one watch, we place two together, having sounds of different character, as for instance one low and grave, and another loud and sharp, and the two arms of the stethophone be placed over them respectively, the sounds of both watches are heard, but the sound of one is heard in one ear, and the sound of the other is heard in the other ear. The loudness of the sound in one ear does not increase the weakness of the sound in the other; or, in other words, the intensity of the sensation produced by the weak watch in the one ear is not reduced by the sensation produced by the loud watch in the other ear.

The sound of a watch ticking continues to be heard in one ear, although a large-sized bell is made to ring at the other; and I have not perceived that the sensation produced by the watch is at all impaired by the bell. A whistling lung-sound heard in one ear, is not rendered less obvious by a loud blowing lung-sound in the other. A hissing murmur at the apex of the heart conveyed into one ear, and a rasping sound at the base conveyed into the other, are both heard without alteration in the ears to which they are respectively conveyed.

By virtue of these two laws,—1st, that sounds of the same character are restricted to that ear into which they are conveyed in greater intensity, and 2nd, that sounds differing in character may be heard at the same time in the two ears respectively, even if they be made to reach the ears in different degrees of intensity,—it is possible to analyse a compound sound, or one composed of two sounds, and to divide it into its component parts. In order to effect a division of a compound sound, it is only necessary that the two sounds of which it is composed may respectively be heard at certain points, in greater and lesser intensity, and that the respective cups of the stethophone be placed at these points. The ear connected with the cup placed where one half of the sound is in greater intensity, hears that half sound only, and the ear connected with the cup placed where the other half of the sound is in greater intensity, hears *that half* sound only. The sound is divided into two parts, and one is heard in one ear, and the other part in the other ear. For example, a compound sound composed of the two sounds of two watches placed together upon a table, with the unassisted ear is distinctly heard in its compound state, and cannot be divided into its two constituent parts. With the stethophone this is readily done. One cup is placed where the sound of one watch is in greater intensity, and the other is placed where the sound of the other watch is in greater intensity, and the result is obtained of one watch only ticking in one ear, and of the other watch only ticking in the other ear. The greater intensity of each watch-sound in one ear has rendered all hearing of it in the other ear impossible, and as each watch-sound in its greater intensity is conveyed to different ears, one is heard in one ear only, while the other is heard in the other ear only. Without the stethophone, or some such instrument, this analysis could not be made; the ordinary stethoscope will not succeed, for wherever it is placed it conveys the mixed or compound sound to one ear. If the naked ear be applied over or upon the watches, the same result follows; and it is the same if instead of two cups of the stethophone we employ only one. This remarkable separation of the components of a sound may be effected also when the sounding bodies are enclosed in a box capable of transmitting sound, or when separated from us by the interposition of materials capable of conducting sound; and by successive trials and comparisons of intensity at different places, and by a process of exclusion of those parts which fail to cause sensation, the respective positions of two adjacent sounding bodies may be predicated. If, for example, we have two watches, A and B, enclosed in a box, and through one cup, A, we hear watch A, and with the other cup, B, we hear watch B, we may conclude that cup A is nearer watch A than cup B is, and so on. In the same manner we may auscultate the morbid sounds of the heart. By cup A, placed at the apex, and cup B placed at the base, we hear separately the morbid sounds of the two parts; for example, a blowing murmur at the apex in one ear, and a rasping murmur at the base in the other ear. This we are enabled to do, although at any intermediate point with the single ear, either with or without a stethoscope, we hear the conjoined two sounds. It is obvious that with the stethophone we not only succeed in separating sound, but that this instrument, or some similar contrivance, affords the only possible means of hearing, with two ears at once, sounds emanating from the same region or surface, for the sides of the head can be applied, of course to the same sounding surface only in turn or succession. With this instrument we, as it were, place our ears in our hands, apply them where we choose, and listen with them both at adjacent or distant points of the same surface, at one and the same instant of time.

It is not unlikely that the property which the stethophone possesses of pointing out with precision where sound is most intense, may be very usefully employed. It seems possible that it might be turned to account in discovering the points where operations in military mining may be going on.

It is, however, in the practice of medicine only that the differential stethophone has been hitherto applied, and it may be here permitted to me to point to some of the chief purposes for which it is adapted, and for which it has been employed.

In respect to respiration, we may compare at once, and without the inconvenience of moving the head, or the ordinary stethoscope, from place to place, the extent of the respiratory sounds in different parts, so that a very minute difference, an excess in one part or a deficiency in another, may with certainty be discovered. Differences in quality, such as softness or roughness, are readily recognised. The increased length and loudness in one part is accurately contrasted with the healthy conditions of another part. In cases where the *in*spiration has been very full in one place, in order to compensate for deficiency in another place, and where the *ex*piration has been long and coarse in the deficient part, I have heard the inspiratory sound only in one ear, and the expiratory sound in the other ear. The sounds were respectively restricted to the two parts, and they alternated in a very marked manner. One part has remained silent while the other has been heard to sound, and this has been silenced when the other has awoke the ear.

The diagram represents the sounds occurring alternately in two sides of the chest in a *consumptive* patient. The dark spots represent the *heard sounds.*

The right side has the inspiration strong, the expiration faint. The left side has the inspiration weak, the expiration coarse.

Healthy. Right side of chest.	Unhealthy. Left side of chest.
Inspir. 1. ▮	Inspir. 1.
Expir. 1.	▮ Expir. 1.
Inspir. 2. ▮	Inspir. 2.
Expir. 2.	▮ Expir. 2.

The influence which the acts of respiration exert in heightening and lowering the murmurs in veins, say of the neck, in persons affected with a thin and watery condition of blood, is well exhibited by placing one arm of the stethophone on the chest and the other upon the veins.

When the respiration in two parts is alike in character, but decidedly louder in one part than in another, the sound in the weak side is lost. While this loss proves, in a very emphatic manner, the important fact of deficiency, it of course for the time deprives us of the opportunity of judging of the quality of the deficient inspiration; but this is readily obviated by removing the cup of the instrument from the full respiring part, and then the deficient respiration is immediately heard through the other cup. Thus while the two sounds, being of like character, and one being more intense than the other, can be heard only in one ear at the same time, an admirable opportunity is obtained for contrasting the extent, and some of the qualities, of the sounds of the two parts, by placing the cups alternately and rapidly upon the two spots respectively. Vocal extussive resonance in two parts of the thorax, is well contrasted with the two tubes employed at once, or in immediate succession.

The sounds of the two sides of the heart, and of the valves of the two great arteries proceeding from that organ, are, by means of the stethophone, very advantageously dealt with. By placing it over the two sides of the heart, or the origin of the two arteries, we ascertain the character and loudness of the sounds of these parts. One cup being placed over the aorta, and the other over the pulmonary artery, if the sounds they collect differ in character, one sound is heard in one ear, and another in the other ear. We may have at the same moment an aortic murmur and a healthy pulmonary artery sound, one sound in one ear, and another sound in the other ear. But when it is desired to listen to each sound singly and in succession, the instrument will still be available, for the cups may be applied singly and in succession, thus affording ample means for contrast.

In cases of disordered heart, in which it is desired to discover whether the sounds of the two sides of the heart are synchronous, the stethophone affords the most satisfactory mode of investigating the fact. With it, we virtually place our two ears over the two sides of the heart; and if one side sounds at all after the other, the fact is made known, and the end of one sound and the beginning of another are clearly and distinctly defined. With the ordinary stethoscope this is impossible; for where one sound is heard, the other may be inaudible, and long before the head or stethoscope can possibly be adjusted at another part, the second sound has taken place, and is long since over.

In conclusion, I may perhaps be permitted to say, that the differential stethophone proves a great auxiliary in examining the heart with the cardioscope or sphygmoscope, which I had the honour to exhibit to this Society two years ago. While the latter instrument exhibits the movements of the heart, the stethophone informs us of their sounds, in a more complete manner than can be otherwise effected; and from the stethophone permitting of auscultating two parts at once, and with the eyes directed to the chest, the relation of the movements and of the sounds, normal or abnormal, of this most important organ is very fully and satisfactorily made out.

In connection with that part of my paper which treats of the restriction of hearing to the closed ear, I desire to add the fact, which I have ascertained within the last few days, that if one ear be closed wholly or partially at its external part, i. e. at the meatus externus, by disease or by congenital malformation, while the other ear is healthy, the sound of the tuning-fork, applied to any part of the head, is heard only in the closed ear. This fact holds, although the closed ear is totally unaffected by sounds conveyed through the external air.

I have further to mention the fact, that all persons, deaf in one ear, whom I have lately examined, with one exception, hear the sound of the tuning-fork applied to the head in that ear only that is deaf to external sounds. A man who has been totally deaf in one ear for thirty years, in consequence of a violent blow upon the head, had the tuning-fork applied over the forehead. He started, and said that he heard only in the ear which had been deaf during that long course of time. In such cases I have been disposed to believe that, amidst other lesions of the organ of hearing, there may be present an obstruction or closure, that a reverberation takes place, and that thus a restriction of hearing is secure for the diseased organ.

ROYAL INSTITUTION OF GREAT BRITAIN,
Friday, February 18, 1859,
SOMERVILLE SCOTT ALISON, M.D.,
ON

CERTAIN AUDITORY PHENOMENA.

[Through the indisposition of Dr. Alison, the subject of the discourse, of which the following is an abstract, was kindly laid before the members by Dr. Tyndall.]

CERTAIN auditory phenomena, bearing upon the correlation of the ears, and possessing some interest, have been recently made out by the employment of a double stethoscope, which has been called the differential stethophone, contrived by Dr. Scott Alison.* This instrument (*see* p. 407), like the first double stethoscope, viz. that of Dr. Leared, is applied to both ears, and has the self-adjustment of that of Dr. Camman of New York. It consists of two tubes for the two ears respectively, each independent of the other, except for purposes of adjustment, manual management and convenience of application. Each tube consists again of two parts, a tube part, and a cup or sound-collecting aperture. The cup, made of mahogany, or other freely vibrating wood, is about one inch in diameter at its mouth, and about one-eighth of an inch in diameter at its proximal extremity. The tube near the cup is made of flexible wire, and is covered with silk; the part nearer the ear is made of metal, and at the aural extremity is furnished with an ear-knob of ivory for insertion into the cavity of the external ear. The bore of the knob and of the metal part of the tube is about one-eighth of an inch in diameter.

An instrument possessing the same acoustic value may be made at much less expense than that above described. A piece of india-rubber tube, about 18 inches long, having a bore of one-fifth of an inch in diameter, may have fitted upon one extremity an ear-knob, and upon the other a sound-collecting cup. Two of these, held together by means of a ring of ivory or steel, will make an excellent differential stethophone or phonoscope.

The differential stethophone was designed with the view of collecting different sounds from two parts of the body at the same time, and conveying them separately to each ear. It formed in reality a stethoscope for each ear, and it differed from all binaural or double stethoscopes hitherto employed, which collected sound through one aperture or cup only. Though the old binaural stethoscopes could not be made differential instruments, the differential stethophone might be made a binaural stethoscope, simply by placing the two sound-collecting cups at the same part of the chest. When this is done, the same auditory result is obtained as when the simple binaural stethoscope is employed, viz. a full sound and a distinct auditory sensation, fuller than when one ear only is employed. The advantages sought by means of the differential stethophone were, 1st, to give facility in comparing the intensity of the fine breath sound of the lung at two different parts of the chest at the same time; and, 2nd, to ascertain with exactitude the relative commencement and termination of two sounds generated at different parts of the thorax; which hitherto was impracticable: for, as is obvious enough, it is not possible to have one ear at the same moment at two different parts, or to have the two ears in the same plane, which however, is now virtually effected by the differential stethophone. The second object was fully obtained; but the first was not secured when the two ears were simultaneously employed, though by using the two ears in succession this great advantage of comparing the intensity of one part with the intensity of another was fully gained. It was found that the weak or defective respiratory sound of one part produced no sensation in the ear to which it was conveyed when the stronger sound of another part was communicated to the other ear.

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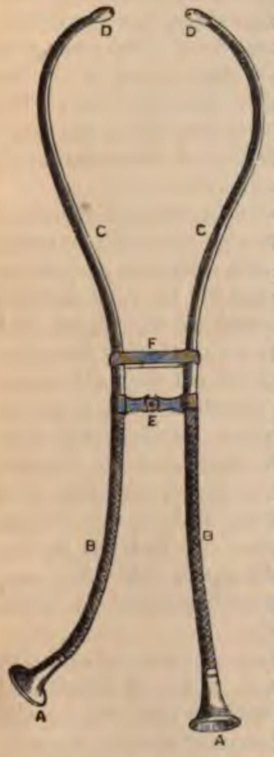
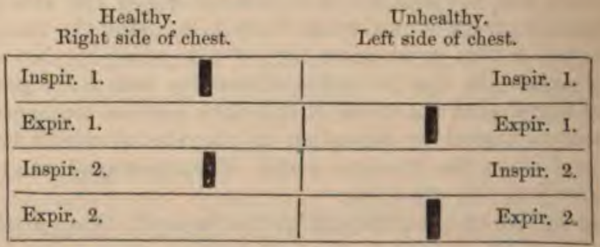
* It is to be observed, that for the differential stethophone to have its properties made available, it is necessary that both ears of the observer should be alike in acuteness.



This failure of the differential instrument, though disappointing at the moment, has led to the ascertaining of an important acoustic principle, and to the practical application of it in medicine, viz. that a major impression made on one ear will prevent all consciousness or perception of a minor impression made at the same time on the other ear, by the same sound; and that an impression on one ear which produces a distinct sensation may be made to produce no sensation whatever, by conveying at the same time a major impression of the same sound to the other ear: the sensation obtained through the latter ear totally destroying or obliterating all sensation of the same sound in the other ear. By the same sound is meant the sound proceeding from the same body, as a watch, a bell, or from two bodies of the same kind, as two tuning forks of the same size and note.

Major impressions on one ear prevent sensations of minor impressions on the other ear only in the case of the same sound, and not in the case of sounds of a different character, unless indeed the major sound happens to be very intense and deafening. Therefore the loud sound of one watch and the weak sound of another watch may be distinctly heard in the two ears, one in one ear only, and the other in the other ear only, provided that one ear be favoured with a major impression of one watch, and the other be favoured with a major impression of the sound of the other watch. In this case the stronger impression of either watch nullifies in a sensorial sense the weaker impression; and as the strong impression of one watch is made in one ear and the strong impression of the other watch is made upon the other ear, one watch is heard in one ear, and the other watch is heard in the other.

The principle of restriction of hearing of the same sound to that ear on which a major impression is made is illustrated in respiration. The ear connected with a part where the respiration is weak fails, as has been already stated, to convey any sensation, while the ear connected with a part where the respiration is strong produces sensation.



The diagram represents the sounds occurring alternately in two sides of the chest in a *consumptive* patient. The dark spots represent the heard *sounds*. The right side has the Inspiration strong, the Expiration faint. The left side has the Inspiration weak, the Expiration coarse.

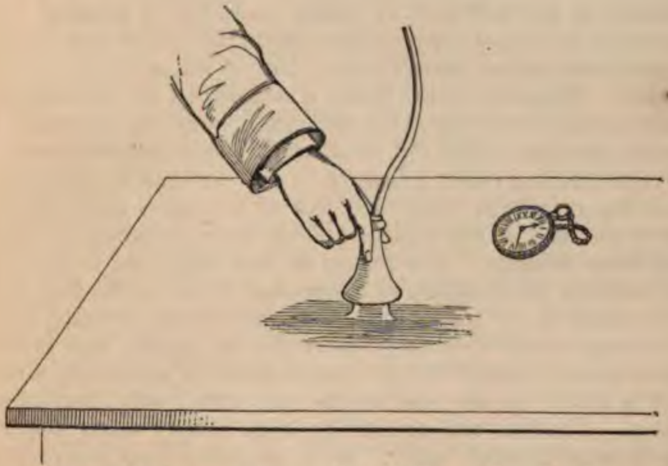
The same principle may be made to perform an important part in the diagnosis of diseases of the heart, accompanied by murmur. If the two cups of the stethophone be applied at two points of the area of a murmur differing in intensity, the sound is heard only by that ear connected with the point where the murmur is more intense. Now, as the source of a murmur is determined by the point of its greatest intensity, it must be obvious that a ready mode of diagnosis is offered. If there be a material difference at the two spots examined, sound is heard only by that ear connected with the more intense point. The test is absolute; for in one ear there is no hearing, and in the other there is hearing. There is consequently no room for error in judgment as to degree, as in the case of consecutive observations with one ear only, with the ordinary stethoscope.

The human ear being capable of hearing many sounds at the same moment (if one be not extremely intense), and as the principle, so to speak, of restriction of hearing to the favoured ear holds in the case of all, it follows that if one can be favoured with a major impression of fifty sounds, they shall all be heard through that ear, and through that ear only. And if some of these fifty sounds be carried in major intensity to one ear, and some in major intensity to the other ear, some of these sounds will be exclusively heard through one ear, and some exclusively through the other ear; a division of sounds thus virtually taking place. Indeed, if we possessed fifty ears, and if of fifty sounds one could be carried in a major intensity to each of these fifty ears, each of the fifty sounds would be heard exclusively through one ear, i. e. each ear would hear one sound exclusively.

This apparent division of sounds may be effected by placing a watch upon a musical box. If both cups of the stethophone be placed so as to receive sound from these bodies equally well, both sounds will be perceived through both ears, and if one cup be placed nearer these two bodies than the other cup, both sounds will be heard in the ear connected with this cup; but if one cup be held a little nearer the musical box than the other cup, and if this other cup be held a little nearer the watch, i. e. if one cup be a little favoured in respect of one sounding body, and the other cup be a little favoured in respect of that of the other sounding body, the musical box will be heard through that ear only which is favoured in respect of it, and the watch will be heard exclusively through that ear that is favoured in respect of that body. When two murmurs occur at the heart, one at the base and another at the apex, possessing as they usually do different characters (say one being "blowing" and the other being "rasping"), and they blend together, they may be thus sensorially separated by placing one cup at the base, and the other at the apex, points of major intensity of the two murmurs respectively.

Of the amount of difference which shall suffice to render one ear as it were sensationless, and to effect a monopoly of sensation in the other, it is difficult to speak with great precision. The difference must be considerable, but need not be very great. In the case of a watch, if one cup be placed fully on the watch, and the other one-third or one-half off it, sensation is limited to the ear connected with the first; if the cup wholly on the watch be now moved off the watch, but kept within half an inch of it, sensation is limited to the other ear; and if the cup half or one-third off the watch be now moved wholly off it, to the distance of an inch or more, sensation is again transferred to the other ear. Transitions of sensation may be thus indefinitely carried on from one ear to the other. This corresponds with ordinary audition: for if we draw a circle around the head in the plane of the horizon, which may be called an acoustic circle, we shall find that on carrying a sounding body round it, binaural sensation is procured only so long as the body is within about 10° on either side of a line drawn forwards and backwards at right angles with the transverse line of the head. In the case then of such a circle we have distinct binaural sensation limited to a region of about 20° in front and 20° behind. The intermediate arcs are the regions of uno-aural sensation; it thus appears that in ordinary audition a moderate superiority in respect of intensity of sound gives a monopoly of hearing to one ear.

The intensity of sound in the ear which has served to give it a monopoly of hearing to the disadvantage of the other ear, has in the foregoing observations been chiefly obtained by greater proximity of one cup of the stethophone to the sounding body over the other; but this may be procured by other means. A superior mode of conduction in respect of one ear over the other, or of one cup of the stethophone over the other, when the ears and the cups are similarly placed in respect of the sounding body, will give a like intensity. A solid rod in the case of one ear, while the atmosphere is the only medium of communication in the case of the other, in respect of a sound of a solid body, will suffice to give the monopolizing intensity. In the same way it has been recently ascertained by Dr. Scott Alison that water placed at the distal extremity of a hearing tube will give an advantage of intensification or of more perfect conduction, sufficient to restrict hearing to that ear favoured with its aid, and to render sensationless the ear connected with the sounding body by means of a hearing tube having *no* water at its extremity to intensify or economize sound by superior conduction. A ring of water between the edge of the hearing tube and the solid sounding body will suffice for this result. The restriction of hearing to one ear is perfect, although the conditions of the ears and of the two limbs of the differential stethophone are precisely alike, with the exception of the ring of water. As we form our notions of sounding bodies being on our right hand or on our left, by perceiving through which ear auditory sensations are acquired, and as water under the circumstances gives an augmentation of sound sufficient to restrict to one ear, an aural illusion may be produced by having two hearing tubes of equal length and of the same conditions brought in contact with two windows respectively, and placing under the cup of one of them a thin bag of water, which may be called a hydrophone. A church bell or a barrel organ will be heard only through the ear connected with the window having the water bag upon it, although these sounding bodies may be nearer the other window. The mind is led to believe that the sounding bodies are nearer the window which is the more distant from them.



In the case of some few sounds, the influence of water in modifying their tone is so great that virtually a sound different in kind is heard. Thus, a watch, in Dr. Alison's possession, gives simply a short ticking sound to that ear connected with one cup of the differential stethophone held in the air; and imparts a full soft tick, or rather tack, and a musical bell sound to the other ear connected with the other cup of the instrument placed upon the thin bag of water lying on the watch. The sound of the watch is so modified by the different media, that, as it were, two different sounds are obtained, a sharp tick, and a full soft tack, and though the watch-sound is conveyed in greater intensity to one ear than to the other, it is heard in both ears. No loss of sensation takes place, as in the case of the same sounding body, sounding through the same medium. The reason of this exception to the law of auditory obliteration, so to speak, is found in the fact that the sound is no longer one, but has become virtually two, by being conveyed through two different media, and it has been already stated that a major impression sensorially nullifies a minor in the case of its own sound only, and of no other. The fine bell sound has been simply made audible by passing through water. It is probable that the double hearing of some persons which has been commented upon by physicians has been due to a difference in the two ears involving a disagreement in the media through which sounds have had to pass. The double hearing referred to has consisted of hearing the sounds of the same sounding body, very different in character in the two ears; the sounds in one ear being soft and in the other sharp, and so on. Perhaps, likewise, certain sounds inaudible in one ear have been rendered audible in the other, as in the case of the fine bell sound above referred to, by passing through better media. It is to be observed, that in order to have a sensation in this manner in both ears the sound must not preponderate greatly in one.

In the case of sounds conveyed to the ear through the bones of the head, a restricting intensity may be procured by closing the aperture of the external ear, as has been observed and commented upon by Mr. Wheatstone. A tuning fork placed upon the middle of the forehead is heard in that ear only that is closed. The closure prevents the escape of sound, and promotes resonance to an extent sufficient to give the restricting intensity. This restriction of hearing to the closed ear in the case of sounds communicated through the bones of the head may be imitated by an analogous closing of the apertures of the differential stethophone. Sounds communicated in equal intensity to both limbs of the stethophone at some point between the closed apertures and the ear knobs are heard louder than when the apertures are open; and if one aperture only be closed, the sounds are heard in that ear only that is connected with the closed aperture. The wetted cotton of Mr. Yearsley — really a cotton and water membrane — and the gutta-percha membrana tympani of Mr. Toynbee, thus applied, greatly increase sounds conveyed to the stethophone at points between the closed apertures and the ear knobs. By closing one aperture with wetted cotton, and the other with gutta-percha, the comparative value of these appliances, so far as intensification of sound communicated in the manner under consideration, may be tested. Both of these appliances have been found extremely beneficial in cases of deafness proceeding from perforate membrana tympani. It would appear that it is by some closure of the passages of the ear in persons partially deaf of one ear, that these persons hear sounds communicated through the bones of the head in that ear only that is deaf, a fact ascertained in an extensive inquiry instituted by the author, and that had been previously observed in a few cases.

When one cup of the differential stethophone is held decidedly nearer a sounding body than the other cup, the sound is perceived, as it were, *in* the ear connected with the nearer cup; but if the further cup be brought somewhat towards the sounding body, so as to obtain more sound, and to be more upon a par with the other cup, the sensation changes its seat, and is felt less *in* the ear and more towards the centre of the head, or the spot midway between the two ears. This centripetal character of sensation is more marked as the two cups attain to a parity, and when this is fully accomplished sensation is located at a central spot. If the cup, which was at first further from the sounding body, be now gradually brought nearer than the other cup, a further transition of sensation is produced; it leaves the central spot and moves towards the other ear, and becomes exclusively located there, as it was exclusively located at the first part of the experiment in the other ear. By alternately and rapidly bringing the cups nearer the sounding body, this movement of sensation may be rendered very striking.

Lastly, the differential stethophone affords an unfailing test of the existence of differences of intensity of sounds communicated by different bodies, solid, liquid, or gaseous. If consecutive trials be required on two bodies, this is done by using the two cups in succession, the necessary movements being effected without changing the position of the head, and with only a very little motion of the fingers. The contrast is readily made, and the difference, if any, with facility discovered. If both limbs of the instrument be simultaneously employed, and if the difference in the amount of the same sound conveyed to the instrument be material, an absolute test is procured at once; for, as has been already explained, no sound will be heard in one ear, and a full sound will be heard in the other. For example, a musical box placed upon the banks of the Serpentine is heard in that ear which is supplied with that limb of the stethophone (an elongated one) whose cup is immersed in the river, and not at all in that connected with that limb whose cup is held upon the ground. In the same way this test of restriction of hearing to one ear, or of uno-aural hearing, is available for deciding upon the comparative acoustic value of different arrangements. If we desire for instance to know whether surrounding a glass with water and another with air both filled with water and previously being equal in communicating sound to the stethophone, gives a difference of sound, the fact is immediately made known. The ear connected with the limb of the stethoscope immersed in the glass surrounded with water hears nothing, while the ear connected with the glass surrounded with air has a distinct sensation. S. S. A.

THE EMPLOYMENT OF WATER IN AUSCULTATION.

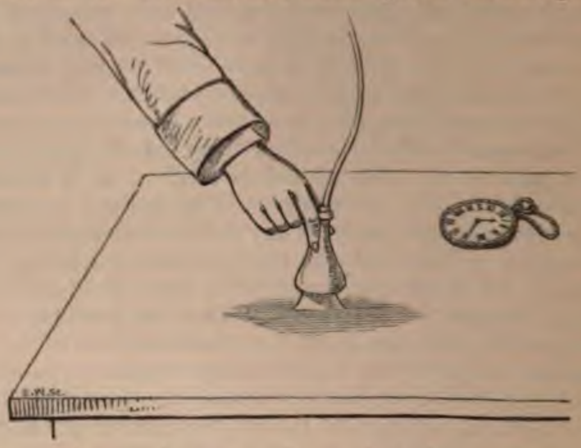
[*From the Medical Times and Gazette, July* 2, 1859.]

WHEN lately engaged in performing experiments upon the propagation of sound, I ascertained that water placed between the aperture of a hearing-tube and a solid sounding body, gave an increase to the sound conveyed to the ear without it, and that a sound so near as to be inaudible without water so interposed was made audible by the addition of this medium of communication. For example, — a watch placed upon a table would be moderately well heard when listened to through a hearing-tube with its aperture placed immediately upon that table; but would be better heard when the aperture of the hearing-tube was placed in water lying upon the table; and the sound of a watch removed to some distance upon the table, though not heard by means of the aperture of the hearing tube placed directly upon this body, would be rendered audible by interposing water.

The amount of increase of sound thus procured by the interposition of water is very considerable, and is such as very materially to add to the value of hearing tubes when employed upon the sounds of solid bodies. The increase of sound is very striking; an impression is made upon the mind as if the sound were proceeding from a body greatly larger than it really is; the sound is louder; it is also fuller and softer. If the sounding body be listened to through a double stethoscope, such as my differential stethophone or phonoscope, which has two apertures for conveying sounds separately to both ears; and if in the case of one of these apertures water be interposed, such is the increase of sound so produced, that the mind becomes conscious of the sound in that ear only, having the advantage of the interposed water. The mind now becomes unconscious of any sound in the other ear; although, previous to the employment of the water, the mind was perfectly sensible of it. This phenomenon forms a good test of the water having produced a stronger auditory sensation; for I have ascertained that the same sound conveyed in a major intensity to one ear sensorially nullifies a minor impression from the same sounding body conveyed to the other ear. This is the test of restriction of hearing to one ear, or of uno-aural hearing.

The quantity of water which will give an increase of sound need not be more than a fine film under the hearing tube, and extensive enough to connect the entire circumference of the aperture with the solid sounding body. When water in such small quantity is employed, the increase of sound is made more obvious by holding the aperture of the hearing tube very lightly upon the solid body, and the result may be made still more remarkable by raising the edges of the aperture a very little from the solid body, taking care to preserve the water in contact with its entire circumference, and also in contact with the solid body, the water, in fact, being preserved in the shape of a ring, with one edge in contact with the hearing tube and with the other in contact with the solid body.

In the case of sounds, such as those of a watch, a greater increase of sound is obtained by employing a large quantity of water, such as a tumblerful or a bowlful; but if a very great amount of water be employed, such as that in a large cistern, and the hearing tube be placed at one extremity and the sounding body at the other, no increase may be obtained, and indeed the sound may be rendered inaudible, — for it is well remembered that sound diminishes in the ratio of the square of the distance, and water gives no exception to this law. For an increase of sound to be procured the diminution from distance must be less than the augmentation from the intensifying property of water. In the case of sounds, such as are produced by striking one large stone upon another upon the dry ground, an intensification of sound may be procured, although the water intervening may be many feet in extent.



The increase of sound procured by the interposition of water varies much with the material of which the hearing tube is formed. Wooden and metallic plate tubes, such as are firm or non-flexible, receive no advantage from water; tubes such as the flexible stethoscope and ordinary hearing or speaking tubes acquire a material reinforcement from water, while tubes made of india-rubber gain a very great advantage from the interposition of this medium. It may be stated, as a general rule, that the more a hearing tube becomes a mere air instrument, and departs from the character of a solid conducting instrument, the more water adds to its acoustic value. When a tube, by means of firm solid walls, becomes more of a solid conductor of sound, water becomes less useful, till at last, as in the case of a wooden stethoscope with only a fine bore, it diminishes sound, and acts as a damper.

The construction of hearing tubes materially affects the results obtained from the employment of water. A tube which is provided with an ear-piece that enters the meatus externus serves to show the augmenting property of water more than one having a circular disc to cover the external ear. A cup or expanded extremity, for the collection of sound, serves likewise to increase the reinforcing power of water. The contraction of the tube beyond the cup to the uniform size of the external meatus favours the same result.

Whatever interferes with the free undulations of the air contained in the tube reduces the property of water under consideration. If a piece of membrane of the greatest tenuity be stretched across the tube or bore of the instrument, between the cup or aperture and the aural extremity, the result is materially reduced.

If a tube be converted into a solid body by closing up the hollow part, water far from increasing the sound heard, materially reduces it. A solid rod of wood, such as a ruler or a solid stethoscope, is deteriorated by water employed in the manner under consideration.

The evenness or unevenness of the surface of sounding bodies materially affects the result obtainable from water when hearing tubes are employed. The augmentation of sound is much greater when the surface is rough and uneven, and thus prevents the exact fitting of the cup of the hearing tube upon it.

The consistence of solid bodies naturally affects the result of the employment of water. The effect is greater in the case of hard resisting bodies, such as wood or stone, than of softer bodies, such as leather.

The freedom or constrained position of the cup or the tube, in respect of capability of vibrating, very materially influences the action of water. If the cup be held firmly by the fingers the result is greatly deteriorated. If the cup be pressed to the bottom of a vessel containing water, the sound heard is greatly less when it is kept free in media aqua.

In order that water shall augment sound in the manner under consideration, viz., from solid bodies through hearing tubes, it is necessary that the water come in immediate contact with the aperture of the tube, or be separated from it only by some thin movable or vibrating body, such as thin india-rubber, gutta-percha, or other membrane or other solid body which, in reference to the strength of the sound, shall be small and vibratory. A thin membrane offers little impediment in the case even of a fine delicate sound, but a thin layer of wood, the one fiftieth part of an inch in thickness, will materially counteract the augmenting power of water in the case of a fine sound, such as that of a watch or even of a tuning-fork. The more the intervening solid body is indisposed to vibrate, the more it interferes with the sound-augmenting property of water. For a layer of wood one twelfth of an inch thick, placed between the water and the hearing tube, to admit of the advantage of water being even in some degree manifested, the sound proceeding from the solid body beyond the water must be very loud and capable of violently agitating the water, and the wood placed between it and the hearing tube. Layers of india-rubber offer much less impediment to the augmenting power of water; these, in fact, act as membranes. Thin membranes offer no sensible impediment whatever.

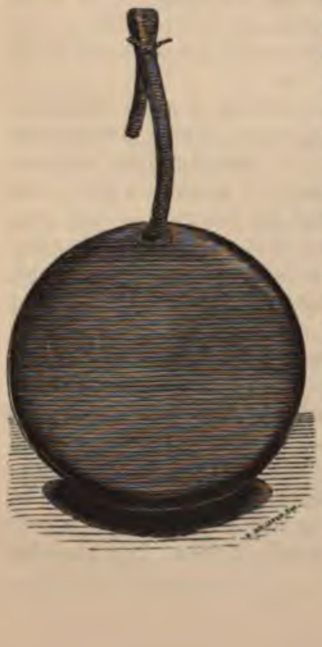
When hearing tubes are to be employed lower than the mere surface of water, and we desire to have the fullest possible amount of sound, it is necessary to close the lower aperture of the tube, so that the water shall not enter into the interior of the instrument. If this be not done no sensible increase of the sound is obtained by carrying the instrument lower in the case of a hearing tube of uniform diameter, or a simple cylinder, and a great reduction of the sound is observed in the case of a hearing tube which is provided with an expanded bell-shaped or other widened aperture, such as the cup extremity of the stethoscope. It is very different with tubes, whether cylindrical or expanding at the apertures, closed with membranes; for the more these instruments are sunk the greater is the amount of sound procured. The increase of sound procured by sinking such an instrument is very great, provided the solid sounding body be not far distant.

In the experiments of M. Collodon, in the Lake of Geneva, in 1826, a cylinder of uniform diameter was employed, and it was closed at the bottom with tin, the same material of which the walls were constructed. It was three yards long and eight inches in diameter. This hearing tube was provided neither with a fine tube to pass into the ear, nor with an expanded extremity for the better collection of sound, so that as a hearing tube instrument it was very defective, having, besides, the disadvantage of a solid bottom. But in some of my experiments upon sound in water proceeding from solid bodies, I have employed an instrument having all the advantages of construction possessed by an ordinary hearing tube, viz., a cup, or expanded extremity or aperture, for collecting the diverging pulses, so to speak, of sound, and to converge them together; a narrow tube to carry these converged pulses, and an open extremity to pass into the external canal of the ear, so that the sonorous pulses, without suffering diminution by escape into the external air, should impinge upon the membrana tympani and the solid walls of the meatus. These advantages of construction in hearing tubes are as desirable in dealing with sounds in water as with sounds in air; and if the precaution above referred to be adopted, are as completely obtainable. When an expanded extremity or aperture is closed with membrane and sunk deep in water, all the sonorous rays which reach the aperture act upon the air within the aperture, and are continued on through the column of air to the ear; but if the membrane be withdrawn, the water rises into the open aperture and reaches to the narrow part of the tube, the area of which may be perhaps only one twentieth of that of the aperture, consequently the sonorous rays or pulses which reach the column of air in the tube are greatly less. Besides this disadvantage, there is another and greater — the free vibration of the materials of the expanded extremity of the hearing tube consonating with the external water in a state of sonorous undulation is very materially impeded, and its reaction upon the contained column of air and upon the surface of the water in contact with the air is interfered with by the presence of the water in the interior. The resistance of the water in the interior is sufficient to interfere with the undulations of the walls of the tube on which so much of the advantage of hearing tubes depends. That the admission of water reduces to a great extent the vibrations of the tube may be at once proved by placing the fingers upon the instrument: the vibrations are sensibly reduced, and may be even rendered altogether imperceptible to the touch.

By the interposition of water between a solid sounding body and the aperture of a hearing tube, sound is conveyed further than by employing simply a hearing tube without water; so that, when it is necessary to convey a sound far through a hearing tube, water may be advantageously employed; but it is not to be forgotten that, whether we employ water or dispense with it, sound is liable to decay, and that, as the distance travelled increases, the intensity of sound diminishes.

These observations having been made, I proceed now to the consideration of the employment of water in the auscultation of the sounds of the human body, and more especially of the morbid sounds of the chest.

THE HYDROPHONE.—If we desire to employ water as an agent in auscultation and in aid of hearing tubes, difficulties at once present themselves. To apply water to the chest is easy enough; but it is not so easy to retain it there in a suitable manner. The application of water may be unpleasant to the patient, and by wetting his clothes may give rise to much annoyance and inconvenience. The idea occurred to me that if I could confine water in some material that would not interfere with its sound-intensifying power, a material advantage would be gained, and we should have a convenient mode of reinforcing hearing tubes. In the preceding part of the paper it was stated that a thin membrane offers no sensible impediment in the way of water intensifying sound, although thick and non-elastic or non-vibrating bodies did, and taking advantage of this fact, I made a waterproof bag of india-rubber to contain water. The india-rubber membrane is so thin as to offer little or no resistance to the undulations of water. The bag is about the size of a large watch, and is sufficient to receive the extremity of an ordinary flexible stethoscope, or to form a medium of connection between the external ear and a solid sounding body such as the human chest. The thickness of the bag is not above the third of an inch. Nothing is gained by greater thickness, and the advantages of sound having to travel only a short way, and also of only a very little weight pressing upon the sounding body, are secured. The sonorous pulses, so to speak, are readily taken up from the solid body or the chest, and are conveyed through the water and membrane on either side, and reach the edge of the aperture of the hearing tube and the contained air, whether the instrument be the flexible stethoscope, the human ear, or any other hearing tube. This instrument possesses valuable advantages, and I have therefore ventured to give it a name, that of the hydrophone. It fits admirably and exactly upon the part of the chest to which it is applied, however uneven and irregular, whether this be a projecting rib or a deeply sunk intercostal space, a broad level surface or a narrow depression, the clavicle or spine of the scapula. By its other side the hydrophone fits as exactly to the aperture of the hearing tube or



to the exterior of the human ear. Every part of the solid body covered by the hydrophone contributes its quota of sound. The fitting of the instrument to the hearing tube prevents the escape of sound from the contained air to the external atmosphere, and by this means resonance of the contained air and of the containing tube is greatly promoted, with the result of a greatly augmented sound. The edge of the hearing tube sits so easily, and with so little resistance from the water-bag, or hydrophone, that the vibrations which are communicated to it are readily reciprocated, and find none or little of that resistance so fatal to its vibrations when pressed upon a solid body.*

The hydrophone may be employed either in aid of the stethoscope, or as a distinct acoustic instrument by itself. In the case of wooden stethoscopes which are solid, applied to the distal aperture, it is injurious by damping sound; in the case of the hollow wooden stethoscope it is of no material value, for water is an indifferent conductor of sound from a solid body to another solid body, and it may be stated that the hollow wooden stethoscope is more a solid than an air instrument. What it gains as an air instrument from the water, is lost as a solid instrument. In fact more may be lost in the one way than is gained in the other.

It is in the case of the flexible stethoscope that the hydrophone forms a material aid in auscultation by hearing tubes. The flexible stethoscope is here meant to signify all stethoscopes into whose construction flexible tubes enter, either forming the whole tube part of the instrument, as in the ordinary flexible stethoscope, or part only, as in Camman's double stethoscope, or my own differential stethoscope. These instruments are essentially air instruments, and I am glad to say that Camman designated his instrument such when he first made it known; for this corresponds with my own investigations. In the case of all these instruments the intensification of sound by the hydrophone is so material, that I have no hesitation in saying that without its employment their resources are by no means fully made available. To have the full benefit of any one of these instruments the hydrophone is essential. Respiratory sounds, healthy and morbid, which are audible with the simple flexible stethoscope, are made more audible when the hydrophone is placed under it. Rhonchi and moist crepitation are strikingly augmented. Vocal resonance, solid and cavernous, dry and moist are in a marked manner amplified. Pectoriloquy accompanied with much vibration of the chest, is increased in a very striking manner. Murmurs of the heart, usually heard in a mitigated form only by flexible stethoscopes — at least in my experience — are conveyed to the ear so as to produce a very distinct and defined sensation. To sum up, it appears to me that flexible stethoscopes, however ingeniously constructed with twisted wire and other contrivances, are, compared with the simple wooden stethoscope, essentially deficient as sound-conveying instruments, some few sounds excepted; but that the hydrophone greatly counteracts this deficiency and brings them up much more to the rank of Laennec's stethoscope. But the inquiry may be made, — What good purpose can the hydrophone subserve under such circumstances, if it can only bring a second-rate instrument nearly up to the position of another? The answer is this, — There are situations and occasions which require the flexible instruments, as is well known, and it is certainly important to render them, defective though they are, as useful acoustic instruments as is possible. It may be possible to place the cup of a flexible tube with a hydrophone under it, where it would be difficult or impossible to employ a wooden stethoscope. In auscultating the sounds of the gravid uterus, or of the fœtus in process of birth, a flexible stethoscope with a hydrophone might possibly afford evidence that would under certain circumstances be very important.

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* A fact which I have very lately ascertained appears to me well worthy of being here recorded. It bears directly upon the importance of perfect freedom of the cup of flexible stethoscopes. A cup held rather firmly upon a piece of wood upon which a tuning-fork is placed gives a fainter auditory sensation than when held loose, but the auditory sensation is further and very materially reduced, if instead of being held firm, the cup be glued to the piece of wood. Here we have perfect continuity but reduced sound. The explanation is found in the reduced vibration.

Pulsating tumours of the chest, too tender to admit of the pressure of the wooden stethoscope, or even of the naked cup of the flexible stethoscope, or upon which it might be dangerous or hazardous to exercise pressure, are well auscultated by means of the flexible stethoscope, provided either with a flat ear-piece or a tubular ear-piece to enter the meatus, having the hydrophone placed under it and upon the morbid part. The hydrophone takes up sound from every part; however uneven it may be, it forms a soft water cushion, and it serves, at the same time, greatly to reinforce sound procured without it. In practice I have on many occasions with the aid of the hydrophone, distinctly heard murmurs of the heart, of the existence of which I had been in doubt when simply employing the flexible stethoscope.

I have observed that when the flexible stethoscope is employed with the clothes of the patient intervening, as is unavoidable under some circumstances, as, for instance, when time does not admit of undressing, or when the patient would suffer by exposure to cold, the impression made upon the ear by lung and heart sounds is greatly enfeebled, and is very unsatisfactory. This evil attendant upon the employment of the flexible stethoscope, including Camman's double stethoscope, and my own differential stethoscope, is obviated, I may say altogether, by placing the hydrophone under the stethoscope. The reinforcement of the sounds is so great as to be quite surprising, as well as very useful. An examination that would be worthless is by the use of the hydrophone rendered satisfactory. This result is obtained partly by a gentle yet efficient pressure exerted upon the clothes, compressing them into less density by excluding layers of air. But a great portion of the result is due to a more complete closure of the aperture of the instrument, attained by a surface of water covered by thin membrane, than can be secured by one of porous and comparatively uneven cloth, &c.

In the examination of children, the employment of the hydrophone, together with the double or the differential stethoscope, is most satisfactory, and is well deserving of notice here. I believe it to be a very great improvement upon the use of the wooden stethoscope, and well worthy of the adoption of the profession in dealing with children. The intensity of sound procured is nearly the same as in the case of wooden instruments. The cup of the stethoscope fits perfectly upon the water, which it can seldom do upon the sharply-curved chest of infants, and thus much economizing of sound is secured. For the same reasons no irregular pressure is endured. The child suffers no pain, and is spared one great source of restlessness and vociferation. Lastly the employment of the hydrophone and a flexible stethoscope causes no alarm, as in the case of the wooden instrument, and is very generally the source of much interest and even amusement to the child, who consequently remains in a state of quietude very favourable for the examination of the auscultator. I constantly examine children with the utmost ease and deliberation in this way, whom I should otherwise have to send away after fruitless efforts at auscultation.

The same method of examination, viz., by the hydrophone and the flexible stethoscope, including Camman's double stethoscope and my differential stethoscope, is very valuable in the case of wasted patients. The employment of the wooden stethoscope with such persons is frequently painful, and is positively cruel. Moreover, as the aperture fits very badly, it is highly unfavourable for the propagation of sound to the ear. Now, the water-pad, or hydrophone, sinks into the hollowed intercostal spaces, and comes into complete contact with the entire circumference of the mouth of the stethoscope, at once collecting more sound, preventing its escape, and obviating the occurrence of painful pressure.

Upon blistered surfaces and parts tender either from internal disease or from external applications, this mode of auscultation is much superior to that by the wooden stethoscope. When an examination by the latter instrument is positively refused, one by the method under consideration is at once permitted as being altogether painless. Many patients, particularly females with tender and wasted chests, have expressed to me their satisfaction with, and surprise at, this painless mode of examination.

A very slight augmentation of sound, in the case of some sounds, is procured by placing the hydrophone on the proximal or aural extremity of the ordinary wooden stethoscope but it is scarcely available in practice.

The bag of water, or hydrophone, as I have ventured to call it, is of service, not only in the case of artificial hearing tubes, but in that of the natural hearing tube, viz., the ear. Applied to the naked chest it forms a stethoscope not materially inferior to the best wooden stethoscope, length excepted. When the part auscultated is very uneven or much curved, by fitting well, it excels the wooden instrument in an acoustic point of view. By fitting well also upon the external ear of the auscultator, and by closing thoroughly the meatus externus, great acoustic advantages are obtained. The sonorous undulations are freely conveyed to every part of the external ear, the air in the meatus comes in immediate contact with the instrument without the possibility of any sonorous undulations escaping. The sonorous undulations of the walls of the tube and those of the enclosed air react upon each other. The water again reciprocates as a sounding-board, and the general resonance is greatly promoted by the thorough closure of the tube. The closure of the meatus is greatly more complete in the case of the water-bag than can be procured by any ordinary wooden disc. The complete closing of the ear, it may be remarked, is useful chiefly by promoting resonance, and not, as has been erroneously taught by some eminent stethoscopists, by excluding other sounds.

The hydrophone forms a great aid to the external ear when the patient is to be examined with his clothes still upon him. As a general rule, good stethoscopists strip their patients for examination, but it may be sometimes desirable to examine through the clothes, as in probably trivial cases, when there is little time, when the patient suffers from cold, or when the examination is only a supplementary one, or when a rough observation will suffice. In such an examination the hydrophone proves of great value: a sound which is very indistinct to the ear placed upon the clothes, becomes full and distinct when the hydrophone is employed. Voice sounds, heart sounds, and rhonchi are greatly improved. Employed in this manner, I am inclined to think the hydrophone is nearly equal to the wooden stethoscope.

The water instrument has this material advantage, that it is very readily moved from one place to another — i. e., from one part of the chest to another. For example, in examining the back, the whole of the surface may be, as it were, run over without once lifting the head, the hydrophone being shifted with the ear upon it from place to place.

In respect of delicacy, the hydrophone is not without some value; for, in the case of females, the interposition of this instrument meets the objection to the imediate contact of the ear of the auscultator with the chest of the patient. When the application of the hydrophone gives annoyance from its coldness, this evil may be readily obviated by placing the instrument in warm water, or by otherwise warming it. Minor advantages of this instrument are its portability and cleanliness.

Other liquids, besides water, tend to intensify sound proceeding from solid bodies, and conveyed to the ear by means of hearing tubes, but none experimented upon have given practically better results. Mercury gives an increase, and the character of the sound is heavy and forcible. Thick glutinous fluids, such as treacle and marmalade, and thick oils, give less increase than water; and much of the fine, liquid, vibrating character of the sound when passed through water is lost.

Some solid bodies serve likewise to give a stronger auditory impression when placed upon other solid bodies, when hearing tubes are employed. Layers of paper, such as a pamphlet, layers of gutta-percha membrane, and thin slices of india-rubber, lard, and butter, give an increase, but it is much less than is obtained from water. In the case of these solid bodies the augmentation is due to two circumstances: 1st, the exact fitting of the instrument upon them; 2nd, the greater amount of its vibration in their case than in that of more solid and resisting bodies. Dr. Sibson has long employed a stethoscope closed with a thin plate of wood, with the effect of rendering valvular sounds more distinct. That I may not appear intentionally to ignore anything that has been done by a professional brother, I deem it right to say, that a water stethoscope was invented some years ago; the name of the inventor I have been unable to discover. I have endeavoured to find some printed details of this instrument, but have failed. Dr. Hamilton Roe and Dr. Markham have informed me that they have seen an instrument so called. It is said to be a solid tube filled with water, but I cannot conceive it could afford any advantage. If water be made to fill the ordinary wooden stethoscopic tube, I am convinced the addition can only serve to spoil the instrument, for this reason — that water in the interior will interfere with the full vibrations of the wood. It is as an adjunct to hearing tubes, or employed as the hydrophone, as previously described, that water can prove of service in ordinary auscultation.

Before concluding this communication, I may be permitted to refer to a point which, though not bearing immediately upon the employment of water in auscultation, yet has suggested itself to several professional friends, viz., the apparent contradiction offered to the sound-propagating properties of water, by the absence or deficiency of respiration and voice sounds in some examples of liquid in the chest, and of heart sounds in examples of effusion in the pericardium.

I would briefly remark, that though water is a good *conductor* of sound, second only to wood and other solid bodies, and better in the case of air tubes as above described, it is yet in many cases opposed to the *production* of sound, and effectually prevents those movements upon which sound depends. A lung pressed upon by water till it becomes impervious to air is not likely to be the seat of respiration sounds, and if they are not produced inside, they cannot be heard outside. *Ex nihilo nihil fit.*

Besides this the circumstances under which the liquid is situated in respect of the stethoscope or hearing tube are different. The liquid in the chest is separated from the hearing tube by the whole thickness of the walls of the cavity; while in the case of the hydrophone and of water employed in my experiments, the liquid is brought in immediate, or almost immediate, contact with the aperture of the stethoscope, a condition which, it was stated in the first part of this communication, is essential to the procuring an augmentation of sound from solid bodies by the intervention of water.

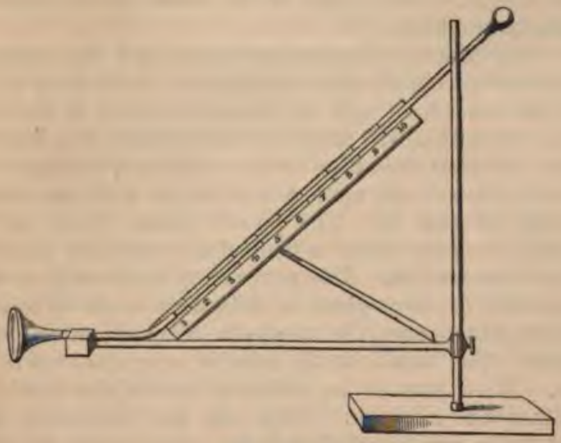
Note.—In reference to the water stethoscope, see more recent information at page 337. Dr. Sibson, in his account of the closed stethoscope, published in the Trans. Prov. Med. Soc. 1844, speaks of the *dissection* of sound. By intensification of sound, the author does not mean an absolute increase of original sonorous undulations; but rather their comparative conservation.—*Feb.* 1861.

THE SPHYGMOSCOPE, AN INSTRUMENT FOR INDICATING THE MOVEMENTS OF THE HEART AND BLOOD-VESSELS.

[*From the Proceedings of the Royal Society, No.* 18, *Vol. VIII., communicated by Dr Owen Rees, F.R.S., and read January* 31, 18, 1856.]

The sphygmoscope (fig. 1) consists of a small chamber containing spirits of wine or other liquid, provided with a thin india-rubber wall, where it is to be applied to the chest. At the opposite extremity the chamber communicates with a glass tube, which rises to some height above the level of the chamber. Liquid is supplied to the instrument until it stands in the tube a little above the level of the chamber.

Fig. 1.



Sphygmoscope.

The pressure of the column of liquid in the tube acts upon the elastic or yielding wall of india-rubber, and causes it to protrude. This protruding part or chest-piece is very readily affected by external impulse; it yields to the slightest touch, and being pushed inwards, causes a displacement of the liquid in the non-elastic chamber, and forces a portion of liquid up the tube. The protruding wall of india-rubber is driven inwards when it is brought in contact with that portion of the chest which is struck by the apex of the heart, and a rise in the tube takes place. When the heart retires, the india-rubber wall, affected by the pressure of the column of liquid in the tube, is pressed back, follows the chest, and permits the liquid to descend. The degree to which the india-rubber wall is forced in by the apex of the heart is denoted by a corresponding rise in the tube, and the amount of protrusion of the india-rubber wall which takes place when the heart retires is denoted by a corresponding fall in the tube. The tube is supplied with a graduated scale to denote the rise and fall with exactitude. The glass tube is provided at the top with some contrivance, such as a brass screw and collar, to prevent the egress of the liquid when the instrument is not in use, or a bulb with an orifice may be supplied. When employed, the glass tube is left open to permit of the passage of the air to and fro.

The sphygmoscope is mounted upon a stand. The chamber and tube are fitted to a horizontal arm, which is made to move up and down so as to carry the instrument to the desired height. The base is so made as to secure the requisite immobility.

The glass tube is a foot or more long, and the round bore is about the one eighth part of an inch. If the bore be much larger, the movement will be inconsiderable; if much less, capillary attraction will interfere and prevent free motion.

When the instrument is to be employed, mounted upon its stand, it is placed upon a firm table with the chamber projecting beyond it. The person whose heart is to be examined is seated upon a firm chair, with his chest erect and free from motion. The protruding india-rubber wall of the chamber or chest-piece is delicately made to touch the fifth intercostal space so as to receive the blow of the apex of the heart. The liquid in the tube is now observed to be in motion. With persons in ordinary health, the liquid rises and falls about an inch. This rise and fall, after taking place three or four times, is followed by a much longer rise and fall to the extent of three or four inches, due to the advancement and retirement of the wall of the chest during the acts of respiration. The shorter rise and fall are again repeated and are again followed by the longer rise and fall caused by the motions of the chest. During the longer rise and fall due to respiration, the beat and the retreat of the heart are still to be recognized by brief interruptions in the rise and fall of the liquid. When difficulty is experienced in obtaining the shock of the heart sufficiently strong to give an appreciable rise and fall, the examinee should make a moderate expiration, and then hold his breath and incline the chest somewhat forward. When the action of the heart is feebly felt at the præcordial region, it may be necessary to apply the instrument to the naked chest; but this is not necessary in the great majority of cases, and it will generally suffice to make the shirt and waistcoat fit tight to the skin. In many trials the sphygmoscope has succeeded in indicating the movements of the heart through the tightly buttoned coat. Thin persons are very favourable for examination; on the other hand, the corpulent less readily affect the instrument.

The movements of the heart, though best indicated at the fifth intercostal space, are to be denoted at other parts of the chest, and in some examples of disease and of large and powerful heart, even in the epigastric region. The moving arm proves convenient in applying the instrument to these parts. In many persons with no very excited heart, it is sensibly acted on at the scapula and infra-dorsal regions.

By means of this instrument the observer can ascertain the frequency of the beats of the heart, but as this can be effected in most cases with accuracy at the radial artery, no particular advantage is gained from it in respect to this point.

The duration of the impulse of the heart upon the chest is well measured by this instrument: the time occupied by the rise, is the time occupied by the impulse. A slow rise after a rapid rise shows a slow beat after a rapid one, and *vice versâ*, a slow fall after an ordinary fall, shows a slow retirement after an ordinary one. An intermittent pulse is marked by an imperfect rise, followed by an ordinary fall, and then by a long rise. The rise is sometimes slower than the fall, which is occasionally found to be abrupt. This is observed when the heart, by reason of its great size, and of the somewhat bent back posture of the thorax, suddenly falls away from the walls of the chest.

The movements of the auricles under ordinary circumstances are not indicated by the sphygmoscope, though when it is placed over them, the liquid in the tube is moved upwards and downwards; but as these movements are synchronous with the movements upwards and downwards of another instrument placed at the apex, it may be inferred that the ventricle is the cause of them all. In some examples of greatly excited heart, as in phthisis, the instrument has revealed movements which seemed to proceed from the auricles; but further observations are required to settle this point, as well as the question whether the movements of the aorta, in a state of excitement, communicate any influence to the instrument.

The instrument, placed upon the heart, indicates strokes of that organ which are so feeble as to have no corresponding pulse at the wrist.

No pause whatever in the movement of the liquid has been at any time observed when the sphygmoscope has been carefully placed so as to receive the full beat, and fall back with freedom. This would go to show that the heart, however slow, is in constant motion, and, contrary to the belief of many physiologists, enjoys no pause. There is certainly no pause in the descent of the liquid, which takes place when the heart retires from the thoracic walls, in the middle of which movement it has been said a very short pause is to be observed in living animals having the heart exposed.

The force with which the heart beats at the fifth intercostal space may be ascertained by closing the upper extremity of the glass tube, and observing the extent to which the enclosed air is compressed.

When the heart is excited, the liquid in the sphygmoscope rises and falls more than usual; but the rise and fall of the excited enlarged heart is much the same as the rise and fall of the excited normal organ. For the most part the enlarged heart gives movements to the instrument when placed upon the ribs and sternum, whilst the normally sized heart affects more exclusively when it is placed upon the fifth intercostal space.

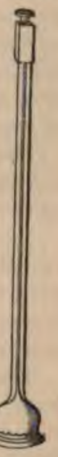
The sphygmoscope indicates with exactitude both the absolute and the comparative influence upon the heart, of food, cordials, stimulants, and tonic medicines. It does the same in respect to depressing causes, such as hunger, cold, and sedatives.

With the aid of this instrument the fact is demonstrated, that the action of the heart may be great when the pulse is small, — that the heart may strike the instrument with force when the pulse scarcely affects the liquid of the hand-sphygmoscope. It affords a remarkable proof that the pulse is one thing and the heart's action another, and teaches that the pulse is only an approximate sign of the state of the heart. It is found also, that while cold at the surface and extremities may depress the pulse, the heart may remain little enfeebled, or even become excited, and that warmth and friction applied to the extremities may cause an excited pulse without there being any accompanying increased force of the heart.

The influence of respiration upon the action of the heart is manifested, in some degree, by the instrument placed over the region of the heart. If the breath be stopped after an ordinary expiration, the movement of the liquid is seen to be increased. If a very long and forcible inspiration be made and the breath then suspended, the movement is somewhat reduced; but when the respiration is again allowed to take its normal course, the movement is seen to be increased for a short time.

The sphygmoscope rises during the first sound of the heart and falls at the second.

Fig. 2.



Hand sphygmoscope.

The sphygmoscope reduced (fig. 2), deprived of its stand, having a level elastic wall instead of protruding one, and having a glass tube with an almost capillary bore, forms a remarkably delicate indicator of the pulse.* It is so delicate in its impressions that it is appreciably affected by the regurgitant wave in the jugular veins, and by the wave in arteries greatly smaller than the radial. From its nicety in manifesting the beat of the blood-wave, it is very valuable, and is called the hand sphygmoscope.

By means of this hand instrument applied to the arteries, a comparison is readily made between the time of the beat of the heart and the rise of the arteries under the influence of the blood-wave. This instrument is much more delicate than the finger in such an inquiry. The impressions made upon the fingers of two hands fail to be conveyed with sufficient nicety to the mind to tell with certainty the relative time of the beat of the heart and arteries. Except in cases of extreme slowness, the sensations obtained from the two hands impressed at nearly the same time, do not admit of a distinct difference in respect to time being made out. It has been to this very defect that the erroneous idea, that the beat of the heart and the beat of the pulse are synchronous, or nearly so, has owed its origin and continuance.

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* Since this instrument was contrived, the author has learned that a sphygmometer of much the same construction was invented some twenty years ago by Mons. le Docteur Herrison, and that a memoir upon it was presented to the Institute of France. The liquid employed was mercury—too heavy to indicate feeble impulses, and the movable wall was of gold-beater's skin, which is inelastic. It may be added, that M. Magendie reported against the practical application of the invention.

The hand sphygmoscope, placed upon the radial artery, shows a rise of the liquid while there is a fall in the sphygmoscope placed over the heart. As the liquid in the one instrument starts from below, the liquid in the other starts from above, and as the liquid in the one reaches the top of its ascent, the liquid in the other reaches the bottom of its descent, to renew their opposing course. The movements in the two instruments at the same instant are always opposed, and the whole time occupied in the movement of one instrument in one direction appears to be occupied by the movement of the other in the opposite direction. The movements *alternate* with as much apparent exactitude as the arms of a well-adjusted balance. When the lapse of time between the beat of the heart and the pulse at the wrist was first observed, suspicion of disease of the aorta was entertained, but the subsequent examination of many persons proved that this alternation was natural. In some twenty persons subjected to examination, the complete alternation has been made out without the shadow of a doubt. These persons were of all ages above childhood, and had the pulse of different degrees of rapidity from 60 to 100.

Hand sphygmoscopes placed upon the carotid, the brachial, the radial, the femoral, and the dorsal artery of the foot, rise at the same instant, and fall at the same point of time.

These facts prove the existence of two great laws not previously enunciated, — 1st, that the heart's beat alternates with the pulse at the wrist; 2ndly, that the pulse of arteries beyond the chest takes place in all parts at the same instant, and without any appreciable interval.

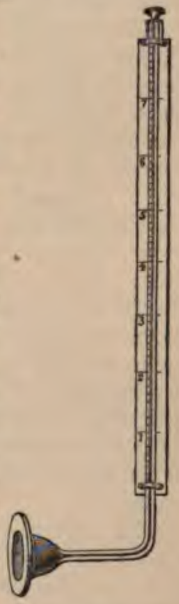
The pulse, it appears, occurs during the retirement of the heart from the thoracic walls, and the collapse or fall of the arteries takes place during the impulse of the heart. During the rise in the hand sphygmoscope placed over the arteries, the second sound of the heart has been distinctly heard, and during the fall, the first, softer and more prolonged sound has been easily distinguished.

The horse has been subjected to examination, to learn the relative time of the beat of the heart and arteries, but the respiratory movements and the motions of the animal have hitherto restricted the application of the instruments. However, it has been most distinctly ascertained, by the hand placed upon the heart and upon the plantar artery, that between the beat of these parts there is a decided interval. The slowness of the action of the heart in the horse renders this experiment less open to error than in man. In these experiments upon the horse, Mr. Mavor, the eminent veterinarian, gave his valuable aid.

The sphygmoscope forms a good pneumoscope. It delicately measures the rise and fall of the chest in respiration. It likewise declares the relative duration of inspiration and expiration, and may thus prove useful in the detection of incipient phthisis, and other pulmonary diseases. When the liquid has attained its highest elevation at the end of inspiration, it immediately begins to fall; but when it has reached the lowest point at the end of expiration, it remains there some instants. The ascent is slower than the descent. After the fall of an ordinary expiration, a forced expiration gives a second fall.

The sphygmoscope may be employed without a stand, and is then more portable (fig. 3), but from the want of a fixed basis, and from the motion of the ribs on which it must rest, its manifestations are less extensive and satisfactory. It may be maintained *in situ* with an elastic band placed around the thorax. When employed without a stand, as it must rest upon the ribs, the elastic wall of the chamber should be plain, and not protruding.

Fig. 3.



The hand sphygmoscope is an exceedingly delicate instrument, but requires great care and nicety in its construction. It may be made by taking about an inch and a half of a gutta-percha tube, half an inch in diameter, slightly widening one extremity of it to make a chamber large enough to hold a small horse-bean, and fastening with thread a piece of thin india-rubber, or of Bourgeaud's india-rubber bandage, securely over it for the elastic and movable wall. The liquid is now supplied, and the glass tube, with a very fine flat bore, say $\frac{1}{10}$th of an inch, and provided with a ring of india-rubber, obtained by cutting off a small portion of a fine india-rubber tube, for a "washer," is now inserted and the instrument is ready for use. The hand sphygmoscope discovers the blood-wave in regurgitation of the jugular veins; it responds to the radial of the newly-born infant; it rises and falls with the movements of the brain of the infant, though some months old, as that organ rises and falls under the influence of its arteries. There is no doubt that, applied to the fontanelles before delivery, it will inform the obstetrician whether the fœtus be dead or alive, and, in cases of difficult labour, supply important evidence for his guidance.

The hand sphygmoscope applied to the radial artery, and to the fontanelles of a dying infant three months old, has indicated to the author the influence of respiration upon the circulation. During inspiration, the column of liquid in the tube was found to fall as if sucked down, and during expiration to spring again.

In practical surgery, the hand sphygmoscope may possibly be employed with advantage, for it will rise with the wave or fluctuation of liquid tumours. It may be placed where the fingers cannot reach. The rise in the instrument is greater in liquid than in aeriform tumours on account of the compressibility of air, and the fall is more rapid and decided when the contents of the tumour are liquid.

For the most part, the hand sphygmoscope is best applied simply with the aid of the fingers. It is delicately held between the tips of the thumb, fore and middle fingers, the nails resting on the examinee. The elastic wall is on no account to be pressed down with a dead weight upon the vessel. It is to be nicely lowered to the level of the artery when collapsed. When the artery rises, it will strike the elastic wall, and as the chamber is fixed by the fingers, the entire blow is communicated to the liquid and it rises in the tube. During the retirement or collapse of the artery, the elastic wall resumes its level condition and draws the liquid down the tube. This motion of the liquid allows the instrument to be employed though the open end of the tube be dependent. When it is desired to avoid the varying pressure experienced when the instrument is held between the fingers, some such apparatus as was invented by Dr. E. S. Blundell, or an elastic band suitably applied around the wrist, will be useful.

The sphygmoscope is for several purposes rendered more convenient of application by interposing, between the chamber and the glass tube, a piece of india-rubber tube of suitable bore and length. In this way the comparison of the beat of the heart and the pulse of an artery is much facilitated, for the glass tubes of the two instruments employed may be brought parallel and close to each other, so that the opposite motions of the liquids in the two tubes are, by near contrast, rendered easier of observation. In employing this adaptation, care must of course be taken that the india-rubber tube is of the same calibre and length in both instruments.

It is hoped that the sphygmoscope will aid in the acquisition of additional knowledge of the movements and condition of the heart, the situation of which within a case of bone, wisely provided to secure it from injury, has this disadvantage for the physiologist and physician, that the action and condition of the organ are with difficulty made out. By means of the sphygmoscope, that small amount of movement which is manifested at the exterior of the chest may be rendered more appreciable to our senses, and more available for physiological and curative purposes; and perhaps information may be obtained by this instrument which has hitherto been procurable only by the practice of vivisection.

NOTE.—By means of Dr. Upham's sphygmosphone, minute intervals have been recently made out between the pulsations of the arteries. (See p. 346: and M. Groux's Memoir on *Fissura Sterni*, Hamburg, 1859.)

SPHYGMOSCOPES: THEIR CONSTRUCTION, OBJECTS, AND MODE OF EMPLOYMENT.

[*From the Medical Times and Gazette, No.* 444, *January* 1, 1859.]

THE engraving below (from the "Archives of Medicine"), for which I am indebted to the kindness of Dr. Beale exhibits all the sphygmoscopes which I have contrived and employed, with the exception of one which is mounted upon a stand. A sphygmoscope or sphygmometer was invented some twenty years ago by M. Herrison, a French physician, and was employed by him to indicate the pulsations of the ateries. In general construction it resembled the instrument fig. 1 in the engraving, was filled with mercury and supplied with a stopcock. More recently a very complicated instrument has been employed in Germany for the purpose of tracing or registering the successive pulses of the arteries.

The instruments which I contrived, and described in the proceedings of the Royal Society for January 1856, are very simple, and are designed and adapted for indicating the pulsations of the heart as well as the arteries. They consist of a cup closed at one end, with a thin lamina of vulcanized india-rubber, and having a tubular termination at the other extremity. The tubular part in the artery sphygmoscope, fig. 1, is prolonged in the direction of the axis of the cup; in the heart sphygmoscope, fig. 2, it is bent at right angles. The tubes are graduated. To admit of the heart sphygmoscope being moved so as to be easily seen while the observer is listening to the sounds of the heart, a piece of flexible india-rubber tubing is inserted between the cup and the graduated glass tube, as is seen in fig. 3; and for the purpose of bringing the glass tube of the artery sphygmoscope parallel

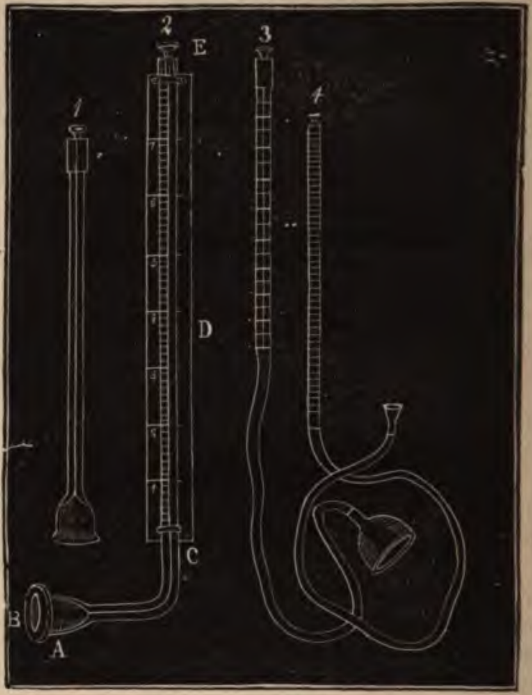


Fig. 1. Artery sphygmoscope. Bore of tube 1-16th of an inch.
Fig. 2. Portable heart sphygmoscope. A, glass cup. B, lamina of india rubber. C, glass tube; bore 1-10th of an inch. D, graduated scale. E, screw stopper.
Fig. 3. Heart sphygmoscope supplied with india-rubber tube.
Fig. 4. Artery sphygmoscope supplied with india-rubber tube.

with the glass tube of the heart sphygmoscope, for the better observation of the relative times of the cardiac and arterial pulsations, a similar provision of india-ruber tubing is made, as appears in fig. 4.

The cup and tubes are filled with coloured water.

These instruments have served to exhibit the following facts: —

1. The extent, frequency, duration, regularity or irregularity of pulsations.
2. The alternation of the pulsations of the heart with those of the arteries.
3. The synchronism, or approximate synchronism of the pulsations of all the arteries of the body.
4. The synchronism of the first sound and impulse of the heart.
5. The synchronism of the second sound and the first part of the retirement of the heart.
6. The simultaneous impulse of both sides of the heart.
7. The synchronous impulse of the ventricles, and the forcible shock of the auricles in phthisis, when the auricles are brought in immediate contact with the front of the chest from destruction of lung tissue.
8. The synchronism of systolic murmurs, and the impulse of the heart.
9. The synchronism of diastolic murmurs, and the retirement of the heart.
10. The occurrence of frémissement to be almost invariably attendant upon the impulse of the heart; occasionally during the retirement.
11. Very harsh grating friction sounds of the heart to be synchronous with the impulse.

When the relation between the sounds and movements of the heart is the subject of observation, it will be convenient to employ at the same time a flexible stethoscope. In cases marked by both basic and intra-cardiac murmurs, great aid is obtained by employing my differential stethoscope, and placing one cup over the base and the other over the apex of the heart, which is tantamount to placing both ears at one moment over different parts of the heart. The systolic murmur of the intra-cardiac valves is heard in one ear during the ascent of the liquid in the sphygmoscope, and the diastolic murmur of the arterial orifices in the other during the descent of the liquid in the sphygmoscope, the diastolic murmur following immediately upon the conclusion of the systolic. The effect of having the two ears thus disposed is most striking when the diastolic murmur is too faint to be heard at the apex.

When the sphygmoscopes are employed, the stoppers being taken out, the tubes should be held above the level of the cups; if made to depend, some of the liquid may escape. By elevating the glass tube the column of water is raised, and the hydrostatic pressure then becomes sufficient to cause the lamina of india-rubber to project outwards and come better in contact with the pulsating parts. The heart instrument is to be gently pressed upon the part to be examined. It is well to have the cup resting upon two ribs, and to have an intercostal space under the cup. The artery sphygmoscope requires more management. If held by the body of the cup, and its edges be pressed flat down upon the artery, the pulsation of the vessel may be impeded or altogether suspended. It should be held so as to admit of the artery rising and striking the india-rubber lamina, and should not be allowed to press the artery in its fall. To secure this, the thumb, the fore, and middle fingers should, while holding the cup, be made to project about half a line beyond the edge of the cup, and to rest gently upon the body on either side of the artery. By this means the cup will be kept comparatively free to receive the upward blow of the vessel, and the artery will be allowed an opportunity of being filled. Without attention to this procedure, disappointment will certainly be experienced.

When air gets into the instrument, and it is desired to replace it with water, the sphygmoscope is to be held perpendicularly, with the open end of the tube uppermost: the point of the middle finger is now to be placed upon the lamina of india-rubber over the cup, and gently pressed in the direction of the interior of the cup: the air which has sought the upper parts of the instrument will now be expelled, and if the open end of the tube be dipped into a glass containing water, upon the finger being removed, the lamina of india-rubber retiring to its old position will cause water to enter by the tube. In the case of sphygmoscopes supplied with india-rubber tubing, this operation will be expedited by lowering the cup below the level of the open end of the tube; for the hydrostatic pressure will cause the india-rubber lamina to pout or project outwards, and thus more water will enter.

So much for the construction, the objects, and the mode of employing the sphygmoscope. The question may now be put: Is it worth while to incur the trouble of using it, or can we do without it? The assiduity with which the functions of the living body and its morbid actions are now investigated, more particularly by the rising race of physicians, utterly disposes of the question of trouble, and puts to shame the suggestion that exertion might be saved. One need only for a moment contemplate the zeal of the profession displayed in our hospitals and societies, to be satisfied that no trouble will be accounted burdensome which promises to make more obvious to our senses, and more clear to our understandings, the operations of health, or the deviations of disease. If the sphygmoscope can conduce to these ends, assuredly its employment is thoroughly secured in the case alike of both practitioner and teacher.

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